BEACH EROSION CONTROL REPORT ON COOPERATIVE STUDY OF HAMPTON BEACH NEW HAMPSHIRE

CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION, BOSTON, MASS.

AUGUST 14, 1953

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CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION
857 COMMONWEALTH AVENUE
BOSTON 15, MASS.

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August 14, 1953

SUBJECT: Beach Erosion Control Report on Cooperative Study of Hampton Beach, New Hampshire

TO: The Chief of Engineers, Department of the Army, Washington 25, D. C.

SYLLABUS

The purpose of the study is to determine the best methods of preventing further erosion, stabilizing and restoring that portion of Hampton Beach, New Hampshire, which fronts the business center.

The Division Engineer finds that erosion has resulted in a gradual loss of usable beach area and that this loss has intensified the problem of adequately accommodating the large numbers of bathers who flock to this, one of the most popular beach resorts in New England. The erosion has narrowed portions of the beach so that storm waves can now reach, attack and damage the existing sea wall, walk and shore boulevard.

The Division Engineer recommends, subject to certain conditions, that the United States adopt a project authorizing Federal participation by the contribution of Federal funds in an amount equal to one-third the first cost of widening to a general width of 150 feet by direct placement of sand fill approximately 5,200 feet of beach adjacent to and extending northward from Haverhill Street with an added 25-foot widening along 1,250 feet of the northern end of the fill area. The total estimated amount of Federal participation in the above project is $140,000.

BEACH EROSION CONTROL REPORT ON COOPERATIVE STUDY OF HAMPTON BEACH, NEW HAMPSHIRE

I. GENERAL

1. Authority. - This study was made by the Corps of Engineers, United States Army, in cooperation with the Forestry and Recreation Department of the State of New Hampshire under authority of Section 2 of the River and Harbor Act approved July 3, 1930 as amended and supplemented. The request therefor dated June 23, 1950 was approved by the Chief of Engineers on November 14, 1950 under an existing agreement between the United States and the New Hampshire Shore and Beach Preservation and Development Commission. The existing agreement, providing for a continuing study of problems at Hampton Beach, Hampton River and Harbor and Seabrook Beach was approved by the Chief of Engineers on December 12, 1938.

2. Purpose. - The purpose of the study is to determine (1) the best methods of preventing further erosion, stabilizing and restoring the beach fronting the business center and (2) the advisability of adopting a project, the public interest therein and the share of the cost, if any, to be borne by the United States.

3. Prior Reports. - a. - Original Beach Erosion Study of Hampton Beach, New Hampshire. A report dated July 15, 1932 was prepared by the Beach Erosion Board as a result of a formal application for a cooperative beach erosion study by the New Hampshire Shore and Beach Preservation and Development Commission, an official state agency. The Board reported that erosion at the south end of Hampton Beach was serious and there was urgent need for protection. The erosion resulted from migration of the Hampton Harbor inlet, and it was attributed to tidal currents associated with the inlet rather than to longshore currents. The Board recommended: -

(1) For the protection of the southern end of Hampton Beach, and incidentally for reclaiming land, construction of a jetty at the north side of the inlet and placement of sand fill behind the jetty.

(2) For the fixation and improvement of the inlet channel, in addition to the north jetty, construction of a jetty at the south side of the inlet.

During 1934-1935 the State of New Hampshire constructed a series of dikes and jetties to confine the inlet and reclaimed approximately 50 acres of land north of the north jetty by pumping hydraulic fill from Hampton Harbor. The work accomplished was a modification of the work recommended by the Beach Erosion Board.

b. - Continuing Study of Hampton and Seabrook Beaches and Hampton River and Harbor, New Hampshire. A report dated April 15, 1942 was prepared by the District Engineer, Boston, Massachusetts, as a result of a formal application therefor by the same agency which applied for the original study. This report was prepared under the existing agreement which provides for studies to be made on a continuing basis. It was reported that the new jetties and dikes and the sand fill at the mouth of Hampton River successfully stabilized the inlet and protected the southern end of Hampton Beach, that erosion and storm damage were occurring at Hampton Beach in the vicinity of the business center and immediately south thereof and that the harbor had shoaled extensively since the dredging of 1935. The need for protection of Hampton Beach was recognized. No need was found for protection of Seabrook Beach. It was recommended that a seawall be constructed along the business center of Hampton Beach with spur groins extending seaward of the wall and that groins be constructed immediately south of the business center. The State of New Hampshire constructed a new seawall fronting the business center of Hampton Beach and placed revetment along a portion of shore at the south end of the business center during 1946-1947.

4. <u>Location.</u> - Hampton Beach is located in the Town of Hampton in the southeast corner of the State of New Hampshire, 2 to 3 miles north of the Massachusetts - New Hampshire boundary. It borders the Gulf of Maine and the Atlantic Ocean between the Hampton Harbor entrance and Great Boars Head. The study area consists of approximately 1.3 miles of Hampton Beach which extends northward from Haverhill Street almost to the base of the drumlin which constitutes Great Boars Head. The location is shown on Plate 1.

5. <u>Population.</u> - The 1950 census shows that the Town of Hampton has a population of 2,847 people. This population is greatly increased during the summer season. It was estimated, based on a study of recreation property in 1945, that the population served by water supply, including summer population, was 21,500. Between 1945 and 1952 the number of seasonal residences increased from 1166 to 1741, the number of hotels and inns from 72 to 87 and the number of cabins and motels from 10 to 53 indicating that the present summer population greatly exceeds that of 1945. The summer population at Hampton Beach is further increased by large numbers of daily visitors. The size of the summer population and the number of daily visitors is indicated by data included in Appendix I.

6. <u>Description.</u> - Hampton Beach is a popular summer resort located at the northern end of a long sandy barrier bar fronting a wide salt marsh. It extends about 1.8 miles north of the Hampton Harbor entrance to a drumlin known as Great Boars Head. Hampton Harbor is a shallow tidal estuary into which Hampton River flows. The bar extends southward from Hampton Harbor for about 2 miles along Seabrook Beach to the Massachusetts boundary and an additional 3 miles along Salisbury Beach in Massachusetts to the Merrimack River

entrance. The remainder of the bar also in Massachusetts, has a length of about 8 miles and it is known as Plum Island. The bar has an average width of approximately 400 yards, a maximum width of about 1000 yards and a minimum width exceeding 100 yards.

7. The southerly 0.3 of a mile of Hampton Beach belongs to the State of New Hampshire. It is a public bathing beach provided with a large bathhouse and parking area. The shore adjacent to and extending 0.2 of a mile to the north is leased from the Town of Hampton and it is occupied by privately-owned summer cottages. The northerly 1.3 miles of shore is owned by the State of New Hampshire, and it is used for public bathing. This latter shore fronts the business section of Hampton Beach, and it is bordered by a boulevard. Parking and playground areas and a wide promenade between the boulevard and the southerly 3400 feet of beach are protected by a concrete encased, vertical faced, steel sheet pile sea wall. Steps have been provided at regular intervals from the promenade through the sea wall down to the bathing beach. The boulevard north of the steel sheet pile sea wall is closer to the shore, being separated from it only by a narrow walk. The walk is generally constructed integral with and on top of an older concrete sea wall. The walk is a continuation of the promenade to the south. Development landward of the boulevard consists of numerous hotels, guest houses, cottages, cabins, restaurants, shops, refreshment stands, a ballroom, bowling alleys, moving picture theatres and penny arcades. There are additional parking areas behind the business center.

8. The bathing beach varies in width with the character of the development behind it. Along the State bathing beach adjacent to the harbor entrance, the beach width seaward of the bathhouse is about 425 feet. Part of this width consists of grass covered sand dunes. Along the privately-leased beach, cottages are built

closer to the shore so that the beach width diminishes to the north and generally does not exceed 100 feet. In this area, from Bradford to Haverhill Streets, the cottage development projects seaward so that cottages on piles are less than 50 feet landward of the high water line. The State-owned beach immediately north of the cottage development is indented landward. Its width above the high water line fronting the new sea wall along the business section varies between 60 and 85 feet. The sandy portion of this high water beach ends at the north end of the new sea wall. The width of the coarse beach north of the new sea wall is generally less than along the sandy shore to the south. The high water line in this latter area north of the bend in the shore boulevard where it approaches Great Boars Head is close to the old concrete sea wall which fronts the boulevard. The area under study is shown on the United States Coast and Geodetic Survey Chart No. 1206 and the Hampton Quadrangle of the Corps of Engineers, United States Army.

II. STATEMENT OF THE PROBLEM

9. Problem. - The principal problem consists of erosion of the bathing beach fronting the business center north of Haverhill Street. The erosion has resulted in a gradual loss of usable beach area. Hampton Beach is already confronted with a need for more space to accommodate the thousands of bathers who crowd this, one of the most popular beach resorts in New England. The economic importance of the problem is indicated by the fact that during 1952, 61.4 percent of the approximate $10,000,000 valuation of the Town of Hampton consisted of recreation property and this 1952 recreation property value was almost double the value which it had during 1945. Erosion and storm damages occur north of the present sandy beach along the shore extending to Great Boars Head. The beach in this area is narrow and coarse and it fronts an old deteriorating concrete sea wall

which borders the shore boulevard. The State of New Hampshire spent approximately $50,000 from 1940 to 1952 for sea wall and sidewalk repairs and cleaning up of storm debris.

III. FACTORS PERTINENT TO THE PROBLEM

10. Physical Characteristics. - Hampton Beach is a sandy barrier bar fronting extensive marshes. Except adjacent to the Hampton Harbor entrance, the bar has a narrow width of bathing beach in front of cottages and sea walls which border a shore boulevard. In the problem area north of Haverhill Street the sandy bathing beach has a slope above the high water line of about 1 on 12 to 1 on 15 and a slope between the high and low water lines of about 1 on 40. Seaward of the low water line the bottom slopes flatten out considerably. The coarse gravelly shore north of the sandy beach to Profile A' - A' has a slope of about 1 on 10 from above to below the high water line. The foreshore slopes seaward of this steep beach area extending beyond the low water line flatten out to about 1 on 35 at Profile A and 1 on 60 at Profiles A' Intermediate and A'. The normal uprush of waves along the sandy beach does not generally reach the sea wall. The uprush of waves along the coarse narrow beach to the north reaches and damages the sea wall and walk which borders the beach.

11. Hampton River enters the Atlantic Ocean at the south end of Hampton Beach. This river is formed two miles inland by the confluence of the Taylor and Hampton Falls Rivers and several tidal creeks that drain the great salt marshes that run for miles along the coast. The total drainage area served by the rivers and creeks is about 50 square miles. The fresh water run-off is negligible when compared with the tidal prism. The river drains into Hampton Harbor, a naturally shallow estuary, before entering the Atlantic Ocean through an inlet stabilized by two stone jetties.

12. Geology. - The shore line of Hampton Beach is one of submergence of the land with respect to the level of the sea. The beach is almost entirely composed of unconsolidated glacial materials in the form of a barrier bar fronting extensive marshes. The bar at its north end is attached to Great Boars Head, a drumlin composed of clayey till. There are a number of rock outcrops visible along the north end of the beach, at and near the mouth of Hampton River and opposite Seabrook Beach. A more detailed description of the geology of the region, of the shore processes which led to formation of the beach, and of probable future trends is contained in Appendix A.

13. Beach and Bottom Materials. - The shore of Hampton Beach between the Hampton Harbor entrance and the north end of the new sea wall fronting the business district is composed principally of fine sand. North of this sea wall, the beach is characterized by outcrops of bedrock and the shore composition becomes progressively coarser towards Great Boars Head, changing from a gravelly shore to one completely covered with cobbles. At Great Boars Head this coarse blanket contains numerous boulders. Samples taken during a prior investigation in 1932 indicated that offshore material in the vicinity of the harbor entrance was coarser than beach material, that offshore material in depths 10 feet below mean low water opposite the beach was finer than beach material and that beach material at high tide level was finer than at mid-tide level. Tabulations showing median diameters of the 1932 samples taken from Hampton, Seabrook and Salisbury Beaches are included in Appendix B and the sample locations are shown on Plate 1. These median diameters show that beach material was progressively finer to the north of the Merrimack River along Salisbury, Seabrook and Hampton Beaches as far north as Profile A. The classification of surface samples taken at mid-tide level along Hampton Beach during November 1952 are included in Appendix B and their locations are shown on Plate 8. The New Hampshire Dept. of Public Works and Highways, during May

and June 1953, obtained samples from in front of the business district of Hampton Beach and from the northern part of the Hampton Harbor area. Beach samples were obtained down to depths of 2 to 5 feet below the beach surface and harbor samples were obtained by borings driven to penetrations of 4 to 14 feet. The sand in the harbor area was found to be similar in gradation and grain size to that on Hampton Beach or slightly coarser. The median diameters of harbor material varied from 0.32 m.m. to 0.56 m.m. indicating that it is coarser than surface beach material taken from mid-tide level during November 1952 (See sample data on Plate 8).

14. Sources of Material. - Glacial deposits have constituted the principal source of beach materials. The materials comprising the barrier beach were derived from deposits of till and glacial outwash that constitute the hills and offshore deposits of the area. Material eroded from these deposits has been transported and redeposited by shore currents. The drumlin at Great Boars Head was formerly an important source of supply for Hampton Beach. The coarse blanket of cobbles and boulders left around the drumlin by past erosion of the finer materials and the protective structures around the toe of the drumlin have practically eliminated this source. Some material is believed to have been contributed by erosion and movement from offshore drumloidal islands which no longer exist. The visible sources of beach building materials are entirely inadequate to account for the materials composing the entire barrier bar extending southward from Great Boars Head to Cape Ann. The submerged offshore deposits appear to be the most important original source of supply for formation of the barrier beach as a whole and it was probably an important source for the material in Hampton Beach. The present sources for Hampton Beach are shore to the north of Great Boars Head and the offshore area opposite the beach.

15. Tides. - The tides at Hampton Beach are semidiurnal. The mean range of tide at Hampton River is 8.3 feet and the spring range is 9.6 feet. Tides exceed the height of the plane of mean high water on an average approximately as follows: by 1 foot or more 107 times per year; by 2 feet or more 12 times a year; by 3 feet or more, once every 2 years. The maximum storm tide height of 3.9 feet above mean high water was measured at the Portsmouth Navy Yard, Maine, on November 30, 1944. A description and analysis of available tidal observations for the area is contained in Appendix C.

16. Currents. - Current observations made prior to construction of the jetties using subaqueous floats off Hampton Beach from Great Boars Head to and into Hampton River indicated that inlet tidal currents were predominant over wind or littoral currents. These inlet tidal currents became practically negligible to the north of Haverhill Street and to the south of Thompson Rock. Floats opposite the beach away from the influence of the inlet currents indicated average currents varying from 0.03 to 0.45 feet per second and maximum currents in a one-half hour period varying from 0.08 to 0.67 feet per second. Currents in the inlet were measured from the old Hampton River bridge using a current meter. These measurements showed that flood and ebb inlet currents were about equal, that maximum currents occurred at mid-tide and that slack water occurred at times of high and low water within a variation of one hour. The maximum observed mean inlet current in the center vertical was 5.6 feet per second accompanying a tidal range of 10.9 feet.

17. Prevailing Winds. - Wind data from observations of the United States Weather Bureau at Boston, Massachusetts and Portland, Maine and from wind roses in the 5-degree square opposite the study area compiled by the United States Navy Hydrographic Office show

that prevailing winds blow offshore from westerly quadrants. Only about 25% of all winds blow onshore from easterly quadrants. Of these winds, those from the northeast quadrant are slightly predominant over those from the southeast quadrant. A description and analysis of wind data are included in Appendix E and wind roses are shown on Plate 1.

18. <u>Storm Winds</u>. - A summary of gales compiled from records of the United States Weather Bureau at Boston, Massachusetts, shows that 80 out of 160 gales which occurred during the 75-year period, 1870-1945 were northeast gales. A predominance of winds of gale force (39 miles per hour or greater) from the northeast quadrant is indicated by a record of hourly wind speeds and directions at Boston for the period October 1949 to September 1952. Analysis of all available data shows that a high preponderance of the most severe gales which occur at Boston, and therefore, probably at Hampton Beach, approach onshore from the northeast quadrant and that winds of slightly lesser intensity predominantly blow offshore from the northwest and southwest quadrants. A description and analysis of storm wind data are included in Appendix E.

19. <u>Waves</u>. - Waves which approach the shore of Hampton Beach are generated by winds with easterly components of direction blowing across the Atlantic Ocean and the Gulf of Maine. Nova Scotia to the northeast limits the fetch across the Gulf of Maine to about 250 miles.. The Isles of Shoals, 11 miles to the northeast of Hampton Beach afford a small amount of protection from waves generated by northeast winds. Hampton Beach is directly exposed to ocean waves and swells approaching from the east and southeast. Waves and swells approaching from these directions are modified by numerous shoals on the wide continental shelf. Cape Ann, 17 miles to the south affords protection against waves generated by southerly winds. No wave

measurements are available. The United States Navy Hydrographic Office has compiled observed data and prepared sea and swell charts for the North Atlantic Ocean. Sea directions in the ocean area opposite Hampton Beach are predominantly southwest, west and northwest or from directions which have little effect on Hampton Beach. Seas with easterly components approach predominantly from the northeast. High seas which cause the greatest erosion and shore damage occur principally from November through March. A swell diagram compiled from the above Hydrographic Office data is shown on Plate 1. It shows that high and medium swells having easterly components of direction approach predominantly from the northeast. In general, it can be concluded that high waves and swells attack Hampton Beach most frequently from the northeast. Available data does not permit determination of the maximum height of waves and swells.

20. Shore Line and Offshore Depth Changes. - Shore line and offshore depth changes were determined during prior studies for the period between 1776 and 1940 from surveys by the British Admiralty, the United States Coast and Geodetic Survey, the New Hampshire State Highway Department and the Corps of Engineers, United States Army. For this study, changes were determined by comparison of surveys of 1940 and 1952, the latter by the New Hampshire Department of Public Works and Highways. The latter survey consisted of a location of the high water shore line along Hampton and Seabrook Beaches between Profiles A and L and elevations and depths on five previously established profiles along Hampton Beach (Profiles A, B, C, E and E-Int.) and two along Seabrook Beach (Profiles K and L). Comparative shore line and offshore depth contour positions and profiles resurveyed during 1952 are shown on Plates 2-7. A detailed account of changes is included in Appendix F.

21. Prior to 1935 the principal changes at Hampton and Seabrook Beaches were caused by migration or the Hampton Harbor entrance. This migration reversed itself periodically. During northward migrations, the south end of Hampton Beach was rapidly eroded while sand spits and bars trailed northward from Seabrook Beach. During southward migrations, the north end of Seabrook Beach eroded while sand spits and bars trailed southward from Hampton Beach. The harbor entrance was successfully fixed in position during 1935 by construction of two jetties. At the same time approximately 50 acres of land was reclaimed at the south end of Hampton Beach north of the north jetty by placement of sand fill obtained by hydraulic dredging in Hampton Harbor. This reclaimed land is now used as a state bathing beach.

22. Changes in the position of the high water shore line along Hampton and Seabrook Beaches after stabilization of the inlet as shown by comparison of surveys run during 1940 and 1952 were as follows:

<u>a.</u> <u>Hampton Beach - North of Haverhill Street</u>

Erosion and landward movement of 20-30 feet along 950 feet of shore extending 400 feet north to 550 feet south of Profile A.

Little change along the next southerly 700 feet of shore.

Erosion and landward movement of 20-40 feet along 1200 feet of shore extending from 200 feet south of Profile B to 100 feet North of Profile C.

Accretion and seaward movement of about 25 feet along 700 feet of shore extending 100 feet north to 600 feet south of Profile C.

Little change along 250 feet of shore extending north from Haverhill Street.

<u>b.</u> <u>Hampton Beach - Between Haverhill Street and the Harbor Entrance</u>

Accretion and seaward movement of 75-150 feet along 1730 feet of shore from Haverhill Street to 800 feet south of Profile E.

Erosion and landward movement along the southerly 750 feet of shore adjacent to the harbor entrance.

c. Seabrook Beach

Accretion and seaward movement of 30-130 feet along the south shore of the harbor entrance behind the south jetty.

Erosion and landward movement of about 30 feet along 950 feet of shore extending 650 north to 300 feet south of Profile K.

Variable changes along the next southerly 1400 feet of shore consisting of erosion and landward movement of up to 25 feet and accretion and seaward movement of up to 50 feet.

23. The nature of changes out to a depth of 18 feet below mean low water as indicated by comparison of profiles run during 1940 and 1952 are as follows:

Profile	Above High Water	M.H.W. to M.L.W.	M.L.W. to 6-Ft. Depth	6-12 Ft. Depth	12-18 Ft. Depth	Net Change
A	Erosion	Accretion	Erosion	Erosion	Erosion	Erosion
B	Accretion	"	"	"	"	"
C	"	"	"	Accretion	"	Accretion
E	"	"	Accretion	Erosion	"	Erosion
F-Int.	"	Erosion	"	Accretion	Accretion	Accretion
K	Erosion	Accretion	"	Erosion	Erosion	Erosion
L	"	Erosion	"	Accretion	"	Accretion

24. Volumetric Beach Changes. - Volumetric changes along Hampton and Seabrook Beaches between 1940 and 1952 were estimated based on comparative profiles. Volumes above the low water line were adjusted to take into account located high water shore line changes not shown by the profiles because of their wide spacing. Volumes below the low water line out to the 18-foot depth were based on the comparative profiles alone. Because of the wide spacing of profiles, volumes are only approximate. They are believed, however, to indicate the general size of volumetric changes which have occurred along the shore. The volumes were computed for zones defined by the 1952 high and low water lines and 6, 12 and 18-foot depth contours. They are tabulated below.

VOLUMETRIC CHANGES* - CUBIC YARDS - 1940 TO 1952

Location	Above H.W.	H.W.toL.W.	L.W. to 6' Depth	6' to 12' Depth	12' to 18' Depth	Total
HAMPTON BEACH						
Prof. A to B	-1,859	+9,480	-15,200	-29,600	-50,578	-87,757
Prof. B to C	-5,207	-9,117	-9,301	-15,293	-39,259	-78,177
Prof. C to Haverhill Street	+2,800	+5,133	-843	+1,695	-17,916	-9,131
Haverhill Street to Prof. E	+22,519	+844	+6,806	-4,302	-36,295	-10,428
Prof. E to F - Int.	+21,007	-6,904	+11,161	+159	-16,271	+9,152
Prof. F - Int. to North Jetty	+5,622	-20,941	+5,296	+473	+11,978	+2,428
SEABROOK BEACH						
South Jetty to Prof. K	-1,185	+12,778	+38,637	-56,296	-54,637	-60,703
Prof. K to L	-800	+4,504	+38,948	-14,015	-61,193	-32,556

* Plus sign denotes accretion. Minus sign denotes erosion.

VOLUMETRIC CHANGES - CUBIC YARDS - 1940 TO 1952

TOTALS BY BEACH AREAS

Location	Above H.W.	H.W.toL.W.	L.W. to 6' Depth	6' to 12' Depth	12' to 18' Depth	Total
HAMPTON BEACH						
Prof. A to Haverhill Street	-4,266	+5,496	-25,344	-43,198	-107,753	-175,065
Haverhill Street to North Jetty	+49,148	-27,001	+23,263	-3,670	-40,588	+1,152
SEABROOK BEACH						
South Jetty to Prof. L	-1,985	+17,282	+77,585	-70,311	-115,830	-93,259

AVERAGE ANNUAL VOLUMETRIC CHANGES - CUBIC YARDS

Location	Above H.W.	H.W.toL.W.	L.W. to 6' Depth	6'to12' Depth	12'to18' Depth	Total
HAMPTON BEACH						
Prof. A to Haverhill Street	-356*	+458	-2,112	-3,600	-8,979	-14,589*
Haverhill Street to North Jetty	+4,096	-2,250	+1,939	-306	-3,382	+97
SEABROOK BEACH						
South Jetty to Prof. L	-165	+1,440	+6,465	-5,859	-9,653	-7,772

*An average annual sand fill of 704 cubic yards was placed between Profile A and Haverhill Street above high water from 1940 to 1952. Average annual beach losses should therefore be increased by 704 cubic yards in this area. Actual beach changes were therefore as tabulated below.

AVERAGE ANNUAL VOLUMETRIC CHANGES - CUBIC YARDS

PROFILE A TO HAVERHILL STREET (ADJUSTED TO ACCOUNT FOR BEACH FILL)

Above H.W.	H.W.toL.W.	L.W. to 6' Depth	6'to12' Depth	12'to18' Depth	Total
-1,060	+458	-2,112	-3,600	-8,979	-15,293

25. <u>Shore Structures.</u> - Existing shore structures consist of two stone and stone revetted sand fill dike jetties at the Hampton Harbor entrance, a timber pile trestle or breakwater extending northward from opposite Exeter Avenue almost to Boston Avenue and from opposite Bradford Street to Haverhill Street, riprap revetment along the shore end of Haverhill Street and along the embankment for a short distance to the north, a concrete encased steel sheet pile sea wall from the end of the revetment between N and M Streets to just north of Nudd Avenue, the northern portion of the sea wall having a gravity section of concrete. North of this concrete sea wall to Great Boars Head there exists an older concrete sea wall with its toe in places protected by dumped boulder revetment. A detailed description containing dates and details of construction, dimensions, purpose and present condition of the above and other prior structures is contained in Appendix G. Details of the sea wall extending from between N and M Streets to north of Nudd Avenue are shown on Plate 8.

26. <u>Littoral Drift.</u> - The predominant direction of littoral drift along the region from Great Boars Head to Castle Neck is from north to south. Evidence of southward drifting consists of accretion along Salisbury Beach north of the north jetty at the Merrimack River entrance and also along the shore of the Castle Neck region south of Plum Island. Accretion has also occurred along Hampton Beach north of the north Hampton Harbor jetty between Haverhill Street and a shore point about opposite the center of the State bath house, apparently as a result of southward drifting. In general, there is no great predominance of drift in any one direction along this coastal region. Variations in direction of drift probably occur depending upon the direction of approach of onshore winds and the waves which they generate. Waves generally approach approximately parallel to the shore. Observation indicates that this is the case along the sandy portion of Hampton Beach south of Marsh Avenue. North of Marsh Avenue to

27. Littoral drift in the vicinity of the Hampton Harbor entrance is influenced by strong tidal currents and by the formation of a bar opposite the mouth of the inlet. The seaward edge of the bar is convex-shaped. It refracts approaching waves bending them towards the river mouth causing material to drift southward along the south end of Hampton Beach and northward along the north end of Seabrook Beach. Failure of the jetties to impound this littoral drift is due to the fact that they are already filled to the limit of their impounding capacity.

IV. ANALYSIS OF PRINCIPAL FEATURES OF THE PROBLEM

28. General. - The shore line of Hampton Beach is subject to gradual changes. North of Haverhill Street the changes have consisted principally of erosion and loss of beach area. South of Haverhill Street the net effect of changes has resulted in an increase in beach area. Due to erosion of the finer beach materials, the shore in the former area north of Marsh Avenue above the high water line is now composed of outcrops of bedrock and a blanket of gravel and cobbles. This beach is narrow and steep. Storm waves can pass over it during high storm tides and attack and damage the sea wall and hurl debris onto the shore boulevard. South of Marsh Avenue to Haverhill Street, the sandy beach is wider and flatter and the backshore is not so susceptible to storm damages. Gradual southward movement of beach materials has resulted in narrowing of the sand beach and the appearance of increasing quantities of gravel. The sandy beach south of Haverhill Street has benefitted from accretion except adjacent to the harbor entrance where erosion has occurred.

29. Rates of Supply and Loss. - Comparison of surveys made during 1940 and 1952 between Profile A and the Hampton Harbor

entrance shows that the rate of loss of beach, foreshore and offshore material out to a depth of 18 feet exceeds the rate of supply. This is probably also true north of Profile A to Great Boars Head. The estimated average annual loss of material between Profile A and Haver-Hill Street is approximately 15,300 cubic yards landward of the 18-foot depth contour and 1000 cubic yards landward of the high water line. The estimated average annual gain between Haverhill Street and the harbor entrance is approximately 100 cubic yards landward of the 18-foot depth contour and 4100 cubic yards landward of the high water line. Average annual losses along Seabrook Beach between the harbor entrance and Profile L are estimated as approximately 7800 cubic yards landward of the 18-foot depth contour and 165 cubic yards landward of the high water line.

30. Manner of Movement of Material. - Movement of beach material is effected by wave action and by strong tidal currents passing into and out of the Hampton Harbor entrance. The effect of tidal currents decreases rapidly north and south of the harbor entrance and is probably negligible north of Haverhill Street and south of Thompson Rock. Wave generated currents are effective throughout the beach area.

31. The configuration of the shore north of Marsh Avenue is such that waves break obliquely to the shore generating littoral currents which tend to move material southward. Due to the coarsness of the beach, appreciable quantities of material from above high water are probably moved only by storm waves. Movement of the finer material from the foreshore is probably continuous with the largest losses occurring during periods of storm attack.

32. South of Marsh Avenue to Haverhill Street waves approach more nearly parallel to the shore and littoral currents are not as strong as along the adjacent shore to the north. The predominance of prevailing winds and storms from the northeast quadrant causes southward drifting. The fine beach material above high water is more easily moved and consequently more material is lost from this zone than from the same zone along the coarser shore to the north.

33. The shore south of Haverhill Street to the harbor entrance is subject to wave generated currents similar to those between Haverhill Street and Marsh Avenue but refraction of waves by the offshore bar opposite the harbor entrance gives littoral currents a southward component of direction towards the harbor entrance. This area benefits from the movement to it of materials eroded from the northern end of Hampton Beach. Inlet tidal currents have an important effect on movement of materials in this area, particularly close to the harbor entrance. The tidal currents evidently cause scouring at the outer end of the north jetty with consequent movement and loss of beach material from the south end of Hampton Beach adjacent to the jetty while just north of this erosion area southward drifting material deposited along the shore has increased the width of the beach.

34. Tidal currents move material into and out of Hampton Harbor. Flood currents deposit material in the harbor and along the lagoonal shores of Hampton and Seabrook Beaches. Ebb currents deposit material on the bar opposite the harbor entrance and in deep water offshore. Tidal currents pass over the low south jetty and move material from the north end of Seabrook Beach.

35. The greatest portion of the normal supply of littoral drift probably moves along the offshore bar opposite the harbor entrance under the influence of normal wave action and does not reach the northern end of Seabrook Beach. The principal movement of material from the seaward shore of Seabrook Beach is effected by wave generated and tidal currents. The material is largely deposited behind the south jetty and carried over the jetty into the harbor entrance where tidal currents transport it as described above.

36. There has been a net gain of material since 1940 in the beach zone above the low water line along Hampton Beach south of Profile A and along Seabrook Beach as far south as Profile L. During the same period there was a considerably larger net loss of material opposite both beaches between the low water line and the 18-foot

depth contour. This indicates the possibility that offshore material is moved landward to both beaches and contributes to the shoaling of Hampton Harbor and formation of the bar at the harbor entrance.

37. Method of Modifying Rates of Supply and Loss. - The only practicable method of increasing the rate of supply of beach material north of Haverhill Street is by adding material to the beach. The large volume of sand which has accumulated in Hampton Harbor would be a suitable source from which sand could be supplied by hydraulic dredging. Borings taken in the northern portion of Hampton Harbor show that an ample supply of suitable beach building material exists.

38. Breakwater or groin construction or enlargement of the jetties at the Hampton Harbor entrance are not practicable methods of reducing the rate of loss north of Haverhill Street. Breakwater construction would be very costly and could have a detrimental effect on adjacent shore areas. In view of the moderate amount of littoral drift, periodic replacement of beach losses appears to be a more economical method of maintaining the beach than construction of groins. The Hampton Harbor jetties, even if enlarged, are located too far away to have any appreciable effect on the problem area. Increasing the impounding capacity of the jetties could result in interception of beach building material which now supplies that shore to the south which is beyond the influence of the Hampton Harbor entrance and its offshore bar.

39. Design Criteria. - Restoration, protection and improvement of the indented shore north of Haverhill Street should provide that the beach be filled to the general alignment of the adjacent high water shore line to the south with sand of size equal to or greater than that now composing the beach. Tidal observations at the Portsmouth Navy Yard, about 12 miles north of the Hampton Harbor entrance, over an 18-year period, indicate that tides exceeding a height of three feet above the plane of mean high water,

corresponding to a tide of 11.3 feet above the plane of mean low water at Hampton Beach, occur on an average once in two years. At a high tide stage of 11.3 feet, the maximum height of waves reaching the low water line would be about nine feet and two and one-half feet at the high water line. An elevation of berm for the fill of 13 feet above mean low water would be the minimum necessary under these conditions. The quantity of fill to be placed should be determined by the profile condition of the existing beach. For the minimum quantity necessary the volume should be computed assuming a slope of 1 on 15 from the top of the horizontal berm down to an elevation 7 feet above mean low water and 1 on 40 below that elevation. Fill placed in accordance with the above criteria should provide a minimum beach width above the mean high water line fronting the existing sea wall of 150 feet and a beach berm width of about 80 feet.

V. PLAN OF PROTECTION

40. Plan Selected. - The plan selected consists of widening to a 150-foot high water width by direct placement of sand fill, 5,200 feet of shore extending northerly from Haverhill Street with an added 25-foot widening along 1,250 feet of the northern end of the fill area. The details of the plan are shown on Plate 8. The sand fill would restore past losses of beach material. It would approximately double the sand beach area bordering the new sea wall which extends 3,400 feet north of Haverhill Street. It would widen the remaining northerly 1,800 feet of narrow coarse beach thereby providing needed protection for the sea wall, walk and shore boulevard, and it would improve the beach composition making it usable for recreational purposes. The total estimated quantity of fill required is 340,000 cubic yards of which 50,000 cubic yards represents the fill for the added 25-foot widening along the north end of the beach. This added widening is located in the portion of beach from which losses of material are expected

to be largest. The added widening will permit utilization of this fill area as a feeder beach to assist in maintenance of the shore to the south without impairing its protective value. Losses of material will necessitate replenishment of the sand fill to insure maintenance of an adequate width of beach. Losses between Haverhill Street and Profile A, landward of the 18-foot depth contour, computed from comparative surveys run during 1940 and 1952, were approximately 15,300 cubic yards per year. Estimated losses along the remainder of the proposed fill area north of Profile A, also landward of the 18-foot depth contour, based on changes which occurred at Profile A from 1940 to 1952 have been about 7400 cubic yards per year. Periodic replacement of fill losses at a rate of 22,700 cubic yards per year should be sufficient to maintain an adequate width of beach.

41. The direct placement of sand fill along the remainder of the shore extending northward to Great Boars Head to provide a protective beach is not regarded as being practicable. The orientation of the shore here with respect to the angle of approach of waves is such that sand fill would be lost at too rapid a rate. This shore area can best be protected by armoring it against wave attack with riprap revetment and/or construction of a new sea wall. The legislature of the State of New Hampshire has already authorized such construction in accordance with a plan proposed by the New Hampshire Department of Public Works and Highways. The proposed plan provides for extension of the new concrete sea wall now fronting the business district approximately 1200 feet northward and protection of the remainder of the state-owned shore to Great Boars Head by placement of riprap revetment or construction of a riprap mound or wall. It provides for similar construction along North Beach located north of Great Boars Head. The above work would be done in connection with proposed improvement of the shore boulevard and proposed construction of additional parking areas between the boulevard and the shore. The authorized project, exclusive of the boulevard improvement, is estimated to cost

$1,275,000, a portion of which cost represents the State of New Hampshire's estimated share of the cost of a Federal project for protection of Hampton Beach. The Federal project considered, as described in the preceding paragraph, would provide a protective sand beach in front of the proposed concrete sea wall extension and along a portion of the proposed riprap revetment adjacent to it. The parking area and road north of the proposed sand fill can be protected adequately by riprap revetment and a riprap mound or wall generally as authorized by the State legislature. The State of New Hampshire has not requested development of any plan for the area as a part of this cooperative study. The State authorizing act has made appropriation of State funds dependent on adoption of a project by the United States for protection of the beach.

VI. ECONOMIC ANALYSIS

42. General. - Detailed estimates of costs are included in Appendix H. Detailed estimates of benefits are included in Appendix J. Estimates have been made in accordance with OCE letters dated 18 October 1951 and 21 July 1953, subject "Proposed Practices for Economic Analysis," File ENGKW 800.12.

43. First Cost. - The estimated first cost, on current price levels, of restoration, protection and improvement of 5,200 feet of the beach north of Haverhill Street by direct placement of 340,000 cubic yards of sand fill, as shown on Plate 8, is $420,000.

44. Benefits. - The estimated benefits have been adjusted to reflect the real worth of the goods and services gained as a result of the project. Benefits are based on direct damages prevented, on the recreational value of restored and improved public beach space and on the increased earning power of recreational properties. Other benefits, not evaluated, consist of prevention of anticipated direct damages to existing and proposed facilities, (sea walls,

highways, parking areas and buildings which will be endangered by continued erosion), increase in value of recreational property located behind and adjacent to the shore and prevention of loss of existing business returns. Non-evaluated benefits are indicated by economic data in Appendix I, and they are described in Appendix J. Adjusted estimated benefits are as follows:

Direct Damages Prevented	$ 5,830
Recreational	22,030
Increased Earning Power	36,060
Total -	$63,920

45. Interests. - The Federal interest in a shore protection project is considered to be essentially the benefit secured by the United States as a land owner. Non-Federal public interest is defined as, (a) the benefits accruing to a State or political subdivision thereof as a land owner and, (b) the benefits accruing to the general public. Private interest is defined as the benefit derived by individuals or non-public groups of individuals on account of ownership of lands and business enterprises affected. All evaluated benefits included in the preceding paragraph are classified as follows:

Benefit	Federal	Non-Federal Public	Private	Total
Direct Damages Prevented	$0	$ 5,830	$0	$ 5,830
Recreational	0	22,030	0	22,030
Increased Earning Power	0	0	36,060	36,060
Total	$0	$27,860	$36,060	$63,920

46. Allocation of Costs. - The Federal policy for the expenditure of Federal funds for the protection and improvement of shores owned by States, municipalities and other political subdivisions is set forth in

Public Law 727, 79th Congress, 2nd Session. In accordance with this policy, the Federal share of the cost can equal but not exceed one-third of the first cost of construction, but not the maintenance, of works for the protection and improvement of publicly-owned shores. The project considered is for protection and improvement of a shore which is all publicly-owned. First costs, allocated as one-third Federal and two thirds non-Federal are as follows:

Federal share	$140,000
Non-Federal share	280,000
Total	$420,000

47. Annual Charges. - Annual charges are based on the Federal and non-Federal share of the estimated costs on current price levels. Interest has been computed at a rate of 2.5 percent on all funds. A useful life of 50 years has been assumed in determining amortization charges. A summary af annual charges is given below:

Annual Charge	Federal	Non-Federal	Total
Interest and Amortization	$4,940	$ 9,870	$14,810
Maintenance	0	22,700	22,700
Total	$4,940	$32,570	$37,510

48. Justification. - The estimated annual benefits and costs and the resulting ratio of benefits to costs are listed below. The ratio of benefits to costs reflects the real worth of the goods and services gained as a result of the project compared with the goods and services needed for the project.

Estimated Annual Benefits	$63,920
Estimated Annual Costs	$37,510
Ratio of Benefits to Costs	1.7 to 1.0

49. <u>Comments of Local Interests</u>. - Close contact has been maintained during the study with the cooperating agency, the New Hampshire Forestry and Recreation Department, through its Recreation Division, and also with the New Hampshire Department of Public Works and Highways, the official state agency which deals with all engineering matters for the cooperating agency. Several conferences were held. A copy of the draft of the report was loaned to the cooperating agency for review. All interested parties concurred in the desirability and need for the restoration, protection and improvement of Hampton Beach by direct placement of sand fill. A preference was indicated for groin construction for maintenance of the northern end of the fill area instead of the proposed added widening of this area and its use as a feeder beach. Such groin construction had been included in a preliminary plan which had been previously discussed. No serious objection was raised to the proposed plan on this basis, however. All interested parties agreed that the plan recommended in this report was satisfactory and acceptable. The agencies representing the state of New Hampshire strongly favor adoption of the recommended project.

50. <u>Responsibilities of Local Interests</u>. - The conditions of local cooperation listed below were explained and discussed with the cooperating agency and the Department of Public Works and Highways. No objections were raised to any of the conditions. It was the unanimous opinion that the conditions of local cooperation can and will be met when required. Local interests are required to:

<u>a</u>. Adopt the project described herein;

<u>b</u>. Assure maintenance of the protective and improvement measure during its useful life as may be required to serve its intended purpose;

c. Provide at their own expense, all necessary lands, easements, and rights-of-way;

d. Hold and save the United States free from all claims for damages that may arise before, during or after prosecution of the work;

e. Assure that water pollution that would endanger the health of bathers will not be permitted;

f. Assure continued public ownership of the shore and its administration for public use only;

g. Agree to approval by the Chief of Engineers, prior to commencement of work by local authorities, of detailed plans, specifications, arrangements for prosecuting the work, adequacy of the proposed work and the assurances as listed above.

VII. CONCLUSIONS AND RECOMMENDATION

51. Conclusions. - The Division Engineer concludes that the plan described in Part V of this report and shown on Plate 8 of the drawings is the most suitable method of restoring, protecting and improving that portion of the shore of Hampton Beach extending northward from Haverhill Street. The plan considered is justified by evaluated benefits. Benefits which cannot be evaluated would add substantially to the justification. The nature and amount of public benefits are sufficient to warrant the maximum one-third participation by the United States in the first cost of the proposed construction in accordance with the policy established by Public Law 727, 79th Congress, 2nd Session. No water pollution exists which would endanger the health of bathers. It is advisable for the United States to adopt a project authorizing Federal participation in the construction of the proposed works by contribution of one-third the first cost thereof.

52. Recommendation. - It is recommended that the United States adopt a project for restoration, protection and improvement of Hampton Beach, New Hampshire, generally as described in Part V and as shown on Plate 8 of this report, by authorizing Federal participation by the

contribution of Federal funds in an amount equal to one-third the first cost of widening to a general width of 150 feet by direct placement of sand fill approximately 5200 feet of beach adjacent to and extending northward from Haverhill Street with an added 25-foot widening along 1250 feet of the northern end of the fill area. The recommendation is subject to the conditions that local interests will:

<u>a</u>. Adopt the project described herein;

<u>b</u>. Assure maintenance of the protective and improvement measure during its useful life as may be required to serve its intended purpose;

<u>c</u>. Provide at their own expense, all necessary lands, easements, and rights-of-way;

<u>d</u>. Hold and save the United States free from all claims for damages that may arise before, during or after prosecution of the work;

<u>e</u>. Assure that water pollution that would endanger the health of bathers will not be permitted;

<u>f</u>. Assure continued public ownership of the shore and its administration for public use only.

The recommendations are further subject to the conditions that the adequacy of the work proposed by local authorities, detailed plans, specifications, assurances that the requirements of local cooperation will be met and arrangements for prosecuting the work be approved by the Chief of Engineers prior to commencement of work.

53. The estimated amount of Federal participation in accordance with the foregoing recommendation is $140,000.

L. H. HEWITT
Colonel, Corps of Engineers
Division Engineer

18 Inclosures
10 Appendices
8 Plates

APPENDIX A

GEOLOGY

(From "The Geology of the Coast of Northeastern Massachusetts" by Newton E. Chute and R. L. Nichols)

1. Glacial and Post Glacial Changes in Level. - The New England Coast is a shore line of submergence. Most of the submergence of the land with respect to the level of the sea occurred during the glacial epoch, within the last 1,500,000 years when a series of ice sheets repeatedly advanced and retreated over the area. The amount of submergence increased northward from New York City through New England. It has been estimated that the submergence amounted to at least 1,200 feet in the vicinity of the Gulf of Maine, a body of water bordered by Hampton Beach, and that most of the submergence occurred prior to the advance of the last glacier which melted from the coastal region 25,000 to 30,000 years ago. The retreat of the last glacier was accompanied by a gradual rise in the level of the sea as water was returned to it and also by a slower rise in the level of the land as it was released from the ice load which had covered it. The net result for the Ipswich area, located south of Hampton Beach, was that sea level rose more than 30 feet higher on the land than it occupies today. With continued melting and retreat of the glacier, the land continued to rise at a rate exceeding that of the ocean, resulting in a new stand of the sea 20 feet or more lower with respect to the land than it occupies today. This lowest stand of the sea is believed to have occurred 10,000 to 15,000 years ago. Since then, sea level has risen to its present position. This last rise in sea level or submergence of the coast may have ceased 3,000 to 5,000 years ago since which time the position of the land relative to the sea has remained essentially stable.

2. Glacial Deposits. - Material picked up and transported by the glaciers and deposited when they melted and retreated from the

area are the chief sources of sand in the New England beaches. The glacial deposits are described as till and outwash. Till deposits are those laid down directly either under the ice or dropped from the ice when it melted. Till is unsorted, unconsolidated heterogeneous material ranging in size from boulders to clay and it is sometimes called boulder clay. Outwash is material which in the process of deposition was acted upon by streams of glacial melt waters. Outwash is, therefore, more or less stratified gravel, sand and silt. The only visible glacial deposit in the vicinity of the shore of Hampton Beach is Great Boar's Head, a drumlin composed of hard, compact, blue colored clayey till. The top and south side of this drumlin is covered by a few feet of roughly stratified cobble and boulder gravel probably deposited on the original drumlin as a kame or kame terrace. Other till deposits reportedly existed at one time as islands opposite Hampton Beach in the form of drumloidal hills but these islands have been consumed by wave action.

3. Bedrock. - The rock that underlies the embayed area between Cape Ann and Great Boar's Head is chiefly Salem gabbro-diorite, Newburyport quartz diorite and Lynn volcanics complex. The above rocks are more easily eroded than the granite and quartzite found at Cape Ann and north of Great Boar's Head. The existence of the embayment between Cape Ann and Great Boar's Head has been attributed to the fact that rocks in this area are less resistant to erosion than those along adjoining shores. Several rock outcrops are visible along the north end of Hampton Beach adjacent to Great Boar's Head, at and near the mouth of Hampton River and one offshore from Seabrook Beach. No other outcrops appear to the south along Salisbury Beach, Plum Island and Castle Neck but they do occur at both ends of Coffins Beach.

4. <u>Origin of Beach.</u> - Hampton Beach is the north end of a barrier sand bar separating salt marshes from the ocean. This bar extends southward from Great Boar's Head including Seabrook and Salisbury Beaches and Plum Island. The bar owes its formation principally to the action of waves which threw up material from the ocean bottom creating bars which retreated landward to form the present beach. The conditions leading to the formation of the barrier beach were favorable. The deposition of clay, outwash sands and gravels and materials brought down by streams obliterated the irregularities in the bedrock surface offshore, thereby forming a gentle, regular seaward slope. Glacial deposits were probably the principal source of sand. Due to this gentle slope, waves broke at a considerable distance offshore, moving sand shoreward and forming ridges parallel to the shore. Continued additions to the ridges or sand bars resulted in the formation of a barrier beach separated from the mainland by a lagoon. This barrier beach migrated landward as a result of wave and wind action and the marsh behind the beach was formed as a result of deposition and shoaling in the lagoon. Material for formation of the barrier beach was also contributed by littoral drifting from Great Boar's Head. Such drifting was probably more important along the north end of the barrier bar which now constitutes Hampton Beach adjacent to Great Boar's Head than farther south. Existing evidence indicates that drifting along the shore is moderate with only a slight predominance in a southward direction. The absence of any large amount of accretion at the updrift side of existing jetties at the mouth of Hampton and Merrimack Rivers and corresponding erosion on the downdrift side as might be expected if there were one predominant direction of drift indicates that no large predominance exists. A general southward drift of beach sands

is indicated by the greater accumulation of beach and dune sands in the southern part of Plum Island and at Castle Neck and Coffin Beaches located south of Plum Island. Some material is also believed to have been contributed by erosion and movement of sand from formerly existing drumloidal islands which no longer exist.

5. <u>Future Trends</u>. - The general tendency of shore currents to move from north to south should result in continued southward movement of eroded material from the north to the south. Retrograding of Boar's Head and beaches located to the north will continue while prograding continues in the Castle Neck region. As the northern area retrogrades, more and more bedrock will be exposed, thereby reducing the supply of material to southern beaches. Hampton, Seabrook, and Salisbury Beaches and Plum Island will also retrograde, a process which should continue for hundreds of years. Eventually, as the supply of material is reduced by exposure of more bedrock, the Castle Hill region will also retrograde. Ultimately, thousands of years from now, the shore line will be far inland of its present position and lined with bedrock cliffs similar to those now found on Cape Ann.

APPENDIX B

BEACH COMPOSITION

1. Available Data - Hampton, Seabrook and Salisbury Beaches. - Sand samples were taken along Hampton, Seabrook and Salisbury Beaches in connection with a prior beach erosion investigation during August 1932. The samples were taken at mean high water level, mid-tide level, and at a depth 10 feet below mean low water. Median diameters of these samples are tabulated below. Samples were taken on profiles designated by letters from north to south along Hampton and Seabrook Beaches and by numbers in the Hampton River inlet channel. Samples along Salisbury Beach were taken on profiles designated by stationing from south to north. Locations of profiles and samples are shown on Plate 1. In addition to the above, six samples of beach materil were taken at mid-tide level along Hampton Beach during November 1952. Median diameters and classifications of these samples are tabulated below and their locations are shown on Plate 8.

SAMPLES ALONG HAMPTON AND SEABROOK BEACHES (1932)
MEDIAN DIAMETERS IN MILLIMETERS

Location	M.H.W. Level	Half Tide Level	10-Ft. Below M.L.W.	Inlet Channel
Profile A	0.165	0.203	0.152	
" B	0.246	0.178	0.140	
" C	0.177	0.406	0.140	
" D	0.229	0.279	0.178	
" E	0.246	0.279	0.152	
" F	0.254	0.457	0.152	
" J	0.279	1.245	-	
" K	0.305	0.267	0.267	
" L	0.292	0.241	0.216	
" M	0.394	0.381	0.267	
Inlet No. 88				1.105
" " 89				0.135
" " 90				0.351
" " 91				0.546
" " 95				0.709

SAMPLES ALONG SALISBURY BEACH (1932)
MEDIAN DIAMETERS IN MILLIMETERS

Location	M.H.W. Level	Half Tide Level	10-Ft. Below M.L.W.
0 + 0	0.533	0.483	0.483
10 + 0	0.546	0.584	0.432
20 + 0	0.445	0.305	0.203
30 + 0	0.483	0.343	0.241
40 + 0	0.406	0.533	0.241
50 + 0	0.546	0.445	0.234
60 + 0	0.429	0.353	0.178
72 + 0	0.483	0.330	0.229
79 + 0	0.343	0.305	0.203
90 + 0	0.279	0.246	0.229
100 + 0	0.279	0.254	0.216
110 + 0	0.279	0.254	0.229
120 + 0	0.305	0.267	0.229
130 + 0	0.279	0.305	0.254
140 + 0	0.330	0.267	0.241
150 + 0	0.279	0.775	0.254
160 + 0	0.254	0.218	0.216
170 + 0	0.254	0.330	0.203
178 + 72	0.279	0.234	0.203

ADDITIONAL SAMPLES ALONG HAMPTON BEACH (1952)

SAMPLE NUMBER	GRAIN SIZE IN MILLIMETERS		CHARACTER OF MATERIAL IN PERCENT		
	RANGE	MEDIAN DIAMETER	FINE SAND	MED. SAND	COARSE SAND
S 1	0.078 - 2.0	0.40	57	43	0
S 2	0.078 - 4.8	0.16	90	9	1
S 3	0.078 - 2.0	0.30	68	32	0
S 4	0.078 - 2.0	0.25	80	20	0
S 5	0.078 - 2.0	0.21	82	18	0
S 6	0.078 - 0.48	0.18	82	15	3

2. Available Data South of Salisbury Beach. - Median diameters of beach sands along Plum Island, Castle Neck, and Coffin Beach extending southward from Salisbury Beach are available from "A Textural Study of Certain New England Beaches," a doctorate thesis by Marshall A. Schalk, Harvard University, 1936. These samples were taken at mean high water level, low to mid-tide level and at the sand dunes. Other samples along the north end of Plum Island and in the Merrimack River entrance were taken during 1952 in connection with a beach erosion investigation of Plum Island. A tabulation of median diameters of all samples along the above beaches is included in the Division Engineer's report on the cooperative beach erosion control study of Plum Island, Massachusetts, dated August 29, 1952.

3. <u>Comparison of Composition of All Beaches Between Great Boars Head and Cape Ann.</u> - All beaches located in the shore indentation extending southward from Great Boars Head to Cape Ann are sandy in composition. The shore along the north end of Plum Island is coarsest in composition. The beaches are progressively finer northward from Plum Island along Salisbury, Seabrook and Hampton Beaches. The composition of the shore of Plum Island is progressively finer from north to south and this change towards finer material continues south and east of Plum Island along Castle Neck and Coffin Beach. Available samples at the high water level indicate that Hampton Beach is finer than other beaches investigated. No samples are available at the high water level at Coffin Beach. Samples taken between the half tide and low tide level at Coffin Beach were finer than those at the half tide level at Hampton Beach, indicating that Coffin Beach may be as fine or finer than Hampton Beach. Samples of offshore material opposite Hampton, Seabrook and Salisbury Beaches were finer than the onshore material. Samples of offshore material in the Hampton River and Merrimack River entrances and opposite the north end of Plum Island are considerably coarser than the onshore material. All samples taken at mid-tide level along Hampton Beach during 1952 were predominantly composed of fine sand. The composition of this sand was progressively coarser from north to south from the approximate position of Profile A to Profile D, was finest in the vicinity of Dover Avenue south of Profile E and was coarsest near Town Rocks north of the north jetty.

APPENDIX C

TIDES

1. General. - The tides at Hampton Beach are semidiurnal. The mean tidal range at the entrance to Hampton River is 8.3 feet and the spring range is 9.6 feet.

2. Tidal Observations. - The nearest station to Hampton Beach for which United States Coast and Geodetic Survey tidal observations covering a long period are available is located at the Portsmouth Navy Yard. Observations at Hampton Beach and at other locations near Hampton Beach are of short duration. The locations and approximate durations of tidal observations in the vicinity of Hampton Beach and their distance from Hampton River are listed below:

Location	Duration of Observations	Distance (miles) from Hampton Beach
Portsmouth Navy Yard, Maine	18 years	12.1
Isle of Shoals, New Hampshire	3 months	11.7
Hampton River, New Hampshire	5 months	0.0
Merrimack River Entrance, Mass.	1.5 months	5.3

3. Highest Tides. - A comparison was made between the 26 highest observed tides at Hampton River for the periods September 4-18, 1928 and July 1-November 31, 1931, and the corresponding high tides for the same period at the Portsmouth Navy Yard to determine whether variations from the mean range of tide were comparable. The largest difference between the variations was 0.2 of a foot and this difference occurred twice. The variations showed a difference of 0.1 of a foot 15 times and were exactly alike 10 times. A similar comparison was made with the Portsmouth Navy Yard observations using the 16 highest observed tides at Gosport Harbor, Isle of Shoals for the periods June 1-July 31,

1928 and September 15-October 17, 1941, and all the high tides observed at the Merrimack River entrance for the period August 15-31, 1928. The maximum difference between variations for Gosport Harbor was 0.2 of a foot and it occurred twice while differences of 0.1 of a foot occurred 6 times and 8 variations were exactly alike. The maximum difference between variations for the Merrimack River entrance was 0.3 of a foot and it occurred once while differences of 0.2 of a foot occurred 6 times, of 0.1 of a foot 14 times, and 10 variations were exactly alike. The excellent agreement between the variations in tidal heights from the planes of mean high water at each location indicates that tides at the Portsmouth Navy Yard are typical of those along this entire area. The frequency of occurrence of tides 1, 2, 3 and 3.5 feet or more above the plane of mean high water was determined from the daily high water observations for the years 1927-1934, 1941, and 1943-1951 at the Portsmouth Navy Yard. It was found that tides exceeded the plane of mean high water by 1 foot or more on an average annual basis 107 times, by 2 feet or more 12 times, by 3 feet or more 0.45 times, and by 3.5 feet or more 0.17 times. The highest tide exceeded the plane of mean high water by 3.9 feet on November 30, 1944. A summary showing the total number of occurrences and the amount of excess for all tides which exceeded the mean height by at least 2 feet for the entire period of record (17.7 years) is given below.

TIDES EXCEEDING MEAN HEIGHT AT PORTSMOUTH NAVY YARD, MAINE

Feet in Excess of M. H. W.	No. Occurrences	Feet in Excess of M. H. W.	No. Occurrences
2.0	52	3.0	2
2.1	42	3.1	1
2.2	40	3.2	1
2.3	18	3.3	2
2.4	18	3.4	0
2.5	14	3.5	1
2.6	10	3.6	1
2.7	3	3.7	0
2.8	2	3.8	0
2.9	5	3.9	1

APPENDIX D

CURRENTS

1. Currents Opposite Hampton and Seabrook Beaches (From Beach Erosion Board report, "Shore Protection at Hampton Beach, New Hampshire" dated July 15, 1932). - Observations of the paths of 56 subaqueous floats off Hampton Beach from Great Boars Head to and into Hampton River and Harbor and off Seabrook Beach to the New Hampshire-Massachusetts line, were made under as many varied conditions of tide, wind, and sea as possible from August to November (inclusive) 1931. These observations indicated that the inlet tidal current predominated over wind or littoral currents but that this predominance decreased rapidly as the distance from the inlet increased. These tidal currents became practically negligible to the north of Haverhill Street and to the south of Thompson Rock. Conditions varied with the range of the tide and the strength and direction of the wind. No eddy current was observed for Hampton Beach but such a current was indicated by several floats at the north end of Seabrook Beach.

2. The average velocity during the time observed and the maximum velocity attained in one-half hour were computed for each float path. Floats observed opposite the beach away from the influence of the stronger inlet tidal currents had average velocities varying from 0.03 to 0.45 feet per second and maximum velocities varying from 0.08 to 0.67 feet per second. In the same sections off the shore, the greatest observed velocity that was unquestionably due to tidal current alone was 0.20 feet per second and it occurred when the range of tide was 9.8 feet. The velocities of floats which were considered to have been motivated primarily by wind currents were found to vary from 0.6% to 1.4%, averaging 1.0% of the corresponding estimated wind velocity, the variation occurring with different lengths of floats. Away from the inlet and seaward of the line of breakers, wind currents predominated. A study of U.S. Weather Bureau wind data indicates

a general though not very great preponderance of northeast winds over southeast winds causing prevailing currents from north to south.

3. <u>Currents in the Hampton River Entrance.</u> - Currents in the inlet were observed by means of a current meter suspended from the old Hampton River Bridge during flood and ebb of the tide in the period August-November 1931. These observations showed: -

(1) That the velocity of the inflowing current on flood tide is approximately equal to the velocity of the outflowing current on ebb tide (the fresh water run-off being negligible).

(2) That the time of maximum velocity occurs nearly at mid-tide and slack water occurs approximately at the times of high and low water, but variations of as much as 1 hour may occur from these times.

(3) That the largest observed value of the mean velocity in the center vertical was 5.6 feet per second accompanying a tidal range of 10.9 feet.

APPENDIX E

PREVAILING WINDS AND STORMS

1. General. - United States Weather Bureau records are available for weather stations at locations which indicate the type of winds which can be expected to occur at Hampton Beach. The nearest station is located at Boston, Massachusetts approximately 39 miles south of Hampton Beach. The other station is located at Portland, Maine approximately 57 miles north of Hampton Beach.

2. Prevailing Winds. - Wind diagrams were prepared based on hourly observations of wind speed and direction at Boston and Portland for the three-year period, October 1949 to September 1952. These diagrams are shown on Plate 1. They both show a high preponderance of duration for westerly winds with the duration larger from the northwest quadrant than from the southwest quadrant. The largest duration at Boston was from the southwest direction while at Portland it was from the west northwest direction. Winds from easterly directions, the only winds which generate waves that appreciably affect the shore of Hampton Beach occurred about 25% of the time at both Boston and Portland. The duration of these easterly winds at Boston was only slightly greater from the northeast direction and quadrant over those occurring from the southeast direction and quadrant. The duration of the easterly winds at Portland was greatest from the north northeast direction and the northeast quadrant, the prevalence over southeasterly winds being more marked than at Boston. Wind roses showing average winds in 5-degree squares for the northeastern United States, compiled from records of the United States Navy Hydrographic Office, are also shown on Plate 1. The rose covering the area including Boston, Portland and Hampton Beach shows a high preponderance of winds from westerly directions, and a predominance of winds from the northeast direction and quadrant over other winds having easterly components. It can be concluded from the above that the prevailing winds blow from westerly directions or offshore with respect to the study area, and that winds which

blow onshore prevail from the northeast quadrant. Means published by the U. S. Weather Bureau in 1952 Local Clamatological Summaries show that winds at Boston prevailed from the northwest direction based on a 17 year record, and winds at Portland prevailed from the south direction based on a 77 year record. This indicates a possibility that the three-year period used above for determination of wind expectancy may be too short to give reliable results.

3. Storm Winds. - A summary of the number of gales compiled from records of the United States Weather Bureau at Boston, Massachusetts, covering the 75-year period 1870 - 1945, inclusive, is given in the following table:

Gales (1870-1945, inclusive)

Direction	N	NE	E	SE	S	SW	W	NW	Total
No. of Gales	3	80	9	14	12	15	13	14	160
Percent of Total	2	50	6	9	7	9	8	9	100

The above gales represent major disturbances accompanied by high wind speeds of long duration. Classification of direction of each gale was made in accordance with the predominant direction of wind. Variations in direction during gales are not accounted for. From the above, it is apparent that there has been a high preponderance of severe northeast gales.

4. A tabulation showing the duration of winds, their direction and speeds compiled from United States Weather Bureau records for Boston and Portland for the period October 1949 to September 1952 is included below:

Wind Speeds and Directions (October 1949-September 1952 inclusive).

Boston, Massachusetts
Number of Hours

Wind Speed (M.P.H.)	0-3	4-7	8-12	13-18	19-24	25-31	32-38	39-46	47 & Over	Total
Direction										
N	21	198	591	445	72	35	4	1		1,367
NNE	21	126	385	306	91	28	6	1		964
NE	30	235	385	390	171	42	18	5	1	1,277
ENE	36	146	238	237	116	28	1	1		803
E	24	167	397	339	118	35	6	14	1	1,101
ESE	28	184	480	327	67	22	2		4	1,114
SE	19	204	451	368	58	4				1,104
SSE	16	208	417	160	30	10				841
S	29	273	498	209	53	23	3	2		1,190
SSW	17	248	555	422	106	23	4	4		1,379
SW	22	440	1,620	1,389	307	62	17	2		3,859
WSW	18	224	691	421	47	2	1			1,404
W	18	261	677	408	55	18	1			1,438
WNW	24	367	1,292	1,026	330	105	14	3		3,161
NW	26	317	945	1,006	418	157	20			2,889
NNW	19	198	756	865	301	81	6			2,226
										26,117

Portland, Maine
Number of Hours

Wind Speed (M.P.H.)	0-3	4-7	8-12	13-18	19-24	25-31	32-38	39-46	47 & Over	Total
Direction										
N	195	861	759	393	60	7	6	3		2,284
NNE	109	419	637	351	40	10				1,566
NE	70	261	266	145	12	7				761
ENE	50	239	224	122	25	13	1			674
E	70	310	326	179	42	16	7	7	2	959
ESE	79	307	275	99	19	8	2			789
SE	72	224	185	86	17	9	1			594
SSE	63	288	350	181	27	28	8	2		947
S	113	628	704	341	34	10				1,830
SSW	146	874	778	316	31	3				2,148
SW	194	980	577	119	3					1,873
WSW	224	978	407	178	21	2		1		1,811
W	299	1141	598	260	69	24	1			2,392
WNW	316	1086	612	332	82	21	1			2,450
NW	280	968	498	305	49	1				2,101
NNW	262	802	556	331	55	7				2,013
										25,192

Even though the length of the records tabulated above is probably too short to give a reliable indication of wind expectancy, it is interesting to note that winds of gale force (39 miles per hour or greater) occurred predominantly from easterly directions, being predominant from the northeast quadrant at Boston and the southeast quadrant at Portland. This predominance of northeast gale winds at Boston is in general agreement with the 75-year record of gales included in Paragraph 3 above. If it is assumed that winds at Hampton Beach are similar to those occurring at the nearest weather station at Boston, it would appear that the most severe gales which occur in this area approach onshore from the northeast quadrant and that winds of smaller intensity predominantly blow offshore from the northwest and southwest quadrants.

APPENDIX F

SHORE LINE AND OFFSHORE DEPTH CHANGES

1. Basic Data. - Maps showing the location of the high and low water lines and the 6, 12 and 18-foot depth contours along Hampton and Seabrook Beaches and in Hampton Harbor and inlet were prepared for prior reports based on surveys by the British Admiralty, the United States Coast and Geodetic Survey, the New Hampshire State Highway Department and the Corps of Engineers, U. S. Army. These maps cover the period between 1776 and 1940. The high water shore line along Hampton and Seabrook Beaches was located for this study during 1952 by the New Hampshire Department of Public Works and Highways. In addition to the data cited above, profiles were established throughout the area during 1931. Elevations and soundings were run on those profiles and on others subsequently established during several years between 1931 and 1940. Seven of the profiles were resurveyed during 1952 for this study. Plans showing shore line and offshore depth changes are included on Plates 2 - 5. Plots of comparative elevations and depths on the profiles resurveyed during 1952 are included on Plates 6 - 7.

2. Early Changes (1776-1931). - The principal changes occurring at Hampton and Seabrook Beaches between 1776 and 1931 were associated with movements of the Hampton Harbor inlet. During 1776, the inlet channel flowed south of Beckman's and White Rocks. In 1885, the channel flowed north of these rocks but south of Gun Rock whence it branched, one channel going easterly north of White Rocks, the other northeasterly on both sides of Town Rocks. Following this northward migration of the inlet, a southward migration occurred so that during 1912 the inlet was again south of Beckman's and White Rocks and was apparently in the most southerly location of record. After 1912, the inlet migrated northward so that by 1931 the inlet was again north of Beckman's and White Rocks. Accompanying each northward migration, Seabrook Beach grew in the direction of migration and attached itself to Beckman's and White Rocks, and the south end of Hampton Beach eroded and

receded northward. During each southward migration of the inlet, Hampton Beach grew in the direction of migration and in turn attached itself to Beckman's and White Rocks while the north end of Seabrook Beach eroded and receded southward. Accompanying and forming part of the foregoing inlet movements, the sand spit at the south end of Hampton Beach shifted over an area extending about 2500 feet in an east-west direction and about 1700 feet in a north-south direction, while the sand spit at the north end of Seabrook Beach moved over an equally large area.

3. During 1931, the northward migration of the inlet was continuing, resulting in erosion of the south end of Hampton Beach. This erosion resulted in the destruction of a built-up area containing cottages, streets and sewers, improvements which were constructed coincident with development of Hampton Beach as an important summer resort in the period preceding 1912 when the beach was growing southward. The rapidity of the erosion after 1912 at the points of maximum loss was as follows:

1912 to 1915	1800 feet
1915 to 1926	650 feet
1926 to 1928	180 feet
1928 to 1931	350 feet, of which over 200 feet occurred after 1930, mainly from one storm.

4. Changes During 1931. - A hydrographic and topographic survey in the vicinity of the Hampton Harbor inlet was made during July 1931. Profiles along Hampton and Seabrook Beaches and in the inlet were established at this time and resurveyed at close intervals between August 1 and November 30, a part of the year in which comparatively calm weather prevails. Study of the survey data indicated the following:

a. The front of Hampton Beach as far south as Haverhill Street changes little.

b. From Haverhill Street to the inlet (Exeter Avenue) there is no erosion and even a slight accretion due to the effect of three rock piles.

c. The greatest erosion takes place at the south end of Hampton Beach, particularly at Exeter and River Avenues.

d. The south shore of the inlet between Beckman's Rock and the bridge changes little, the changes observed being in the shape of the shore line rather than in excess of erosion over accretion or the reverse.

e. The front of Seabrook Beach south of White Rocks changes little.

f. The sands of Hampton Harbor are constantly shifting, the net result being a slight accretion.

A comparison of the 1928 and 1931 low and high water lines appeared to substantiate the above indications except for erosion which extended above Haverhill Street as a result of one severe northeast storm on March 4, 1931.

5. Changes from 1931 to 1940. - Shore line and offshore depth changes were determined from surveys run during 1931, 1933, 1935, 1939 and 1940. The 1935 survey was made upon completion of the construction of the jetties and the pumping of fill onto the southern end of Hampton Beach from the harbor. Changes in the vicinity of the Hampton Harbor inlet between 1933 and 1935 were, therefore, the result of construction and dredging operations as well as of natural shore processes. Changes occurring after 1935 show the effect of the inlet stabilization. A detailed description of all changes between 1931 and 1940 is contained in the report of beach erosion at Hampton Beach submitted by the District Engineer, Boston, Massachusetts, to the Beach Erosion Board on April 15, 1941. These changes were as follows:

a. **Changes in Mean High and Low Water Lines:**

Hampton Beach - Between Profiles A and E. - Erosion and recession of the high water line of up to 90 feet between 1933 and 1939, and up to 60 feet between 1939 and 1940. Erosion at the low water line between 1931 and 1933, changing to accretion between 1933 and 1940 with the movement of the low water line due to accretion varying up to 250 feet.

Hampton Beach - Between Profiles E and G. - Accretion between 1935 and 1939, followed by erosion between 1939 and 1940, resulting in movements of the high and low water lines of up to 70 and 60 feet, respectively, during the former period and up to 110 and 120 feet, respectively, during the latter period.

Hampton Harbor Inlet. - No change in the high water line along the north shore of the inlet adjacent to the jetty and dike between 1935 and 1940. During the same period, the high water line along the south shore of the inlet was generally subject to accretion, resulting in a shore line movement of 50 to 150 feet except between White and Beckman's Rock where some erosion occurred. Sand spits formed and grew westward into the harbor from both sides of the inlet. Changes at and below low water between 1935 and 1940 generally consisted of erosion resulting in landward movement of the low water line and removal or reduction of shoals in the inlet.

Hampton Harbor. - High water line changes between 1935 and 1940 varied in the harbor area with accretion predominant. Accretion occurred in the vicinity of the spits extending into the harbor from the sides of the inlet and also along the southeast part of the harbor. Erosion occurred at the low water line adjoining the highway bridge and along the west side of the harbor. The erosion adjoining the highway bridge was offset by accretion farther west.

Seabrook Beach (White Rocks to Profile M). - Accretion resulting in a high water shore line movement of up to 170 feet occurred between 1931 and 1939. This was followed by erosion between 1939 and 1940 which moved the shore back to its approximate 1931 position. Accretion moved the low water line up to 225 feet seaward between 1931 and 1939, and erosion moved this line up to 100 feet landward between 1939 and 1940 so that the net effect for the entire period was accretion.

b. Offshore Depth Changes:

Hampton Beach - Between Profiles A and D. - Accretion and erosion occurred in varying degrees between 1931 and 1940. Changes were generally small in magnitude. The net effect was accretion along the 6, 12 and 18-foot contours with the largest change occurring at the latter depth.

Hampton Beach - Between Profiles D and G. - Varying changes in offshore depths occurred between 1931 and 1940. The net effect of changes along the 6-foot depth contour was accretion. Erosion generally occurred at this depth during the latter part of the period, particularly between Profiles D and F during 1939-1940. Changes along the 12-foot contour consisted of accretion between Profiles D and F during 1931-1939 with no change from 1939 to 1940, and erosion between Profiles F and G during the entire period. Changes along the 18-foot contour were small and variable during 1931-1939 with accretion predominant while little change occurred from 1939 to 1940 except in eroding areas where erosion continued.

Hampton Harbor Inlet. - During 1931 a bar existed across the entrance of the 6-foot inlet channel separating it from open water. This bar was probably cut through during 1935. In 1939, the bar had reformed and the 6-foot inlet channel discharged across the bar about 400 feet north of its 1931 position. During 1940 the channel discharged across the bar 600 feet north of its 1931 position. This northward migration of the channel also occurred within the inlet. At a point 750 feet east of Profile J, the center-line of the channel between the 6-foot depth contours moved northward 80 feet from 1931 to 1935, 140 feet from 1935 to 1939 and 90 feet from 1939 to 1940. The northerly rotation of the channel was also shown by the 12-foot contours. A landward movement of the 6, 12 and probably the 18-foot contours on the ocean side of the bar indicates that erosion was continuous at the entrance between 1931 and 1940. The channel at the highway bridge maintained its position from 1931 to 1940 with the draw of the bridge north of the centerline of the channel. The width of the channel between 6-foot contours increased from about 400 feet during 1931 and 1935 to 470 feet in 1939 and 530 feet in 1940. Depths of 12 feet generally existed between Profile J and the highway bridge between 1931 and 1940. The length and width of this 12-foot area varied irregularly during this period. Only a small area in the inlet at the highway bridge about 150 feet south of the draw had depths of 18 feet during 1931. No such area existed in 1935, but it redeveloped by 1939 and existed in 1940. This area was larger in the latter two years than during 1931.

Hampton Harbor. - Prior to 1935, Hampton Harbor was shallow and except for several small areas in Hampton River, the 6-foot contour did not extend more than approximately 500 feet west of the bridge. In 1935, a boat basin was dredged in the northeast section of the harbor and depths up to 20 feet were developed. This basin filled in rapidly. A survey during 1939 showed that since 1935 the area within the 6-foot contours was greatly reduced, the area within the 12-foot contour had almost entirely filled in and no 18-foot depths existed.

Seabrook Beach - Between Profiles J-Intermediate and M. - The net effect of all changes between 1931 and 1940 along the 6-foot depth contour was erosion from Profile J-Intermediate to a point 200 feet south of Profile L and accretion from that point to Profile M. The net effect of all changes at the 12-foot depth contour generally consisted of erosion north of Profile K and accretion south of the profile with the accretion in great excess over the erosion. Continuous accretion occurred along the 18-foot contour.

6. <u>Changes from 1940 to 1952</u>. - Changes in the position of the high water shore line along Hampton and Seabrook Beaches and offshore depths on five profiles along Hampton Beach and two profiles along Seabrook Beach were determined from surveys run during 1940 and 1952. Shore line changes are shown on Plate 5 and comparative profiles on Plates 6 and 7. These changes were as follows:

a. <u>Changes in the Mean High Water Line:</u>

<u>HAMPTON BEACH</u>

Location	Length Shore (Feet)	Approximate Change
400 feet north to 550 feet south of Profile A	950	Erosion of 20 to 30 feet
550 feet south of Profile A to 200 feet south of Profile B	700	None
200 feet south of Profile B to 100 feet north of Profile C	1200	Erosion of 20 to 40 feet
100 feet north to 600 feet south of Profile C	700	Accretion of 25 feet
600 to 850 feet south of Profile C	250	Little Change
850 feet south of Profile C to 800 feet south of Profile E	1730	Accretion of 75-150 feet
200 feet north of Profile F-intermediate to the north jetty	750	Erosion up to 70 feet

<u>SEABROOK BEACH</u>

Location	Length Shore (Feet)	Approximate Change
South shore of the inlet behind the south jetty		Accretion of 30-130 feet
650 feet north to 300 feet south of Profile K	950	Erosion of 30 feet
300 feet south of Profile K to 600 feet south of Profile L	1400	Variable-erosion up to 25 feet and accretion up to 50 feet.

b. Offshore Depth Changes. - Movements of the 6, 12 and 18-foot depth contours located closest to the shore during the period 1940-1952 are shown in tabular form below for each of the seven profiles surveyed during 1952.

MOVEMENT IN FEET*

Profile	6-foot contour	12-foot contour	18-foot contour
A (Hampton Beach)	-30	-45	-230
B " "	-125	-190	-750
C " "	-40	+35	-50
E " "	0	-395	-80
F-Int " "	0	+140	+50
K (Seabrook Beach)	+240	-305	-415
L " "	+140	+225	-90

* Plus sign indicates seaward movement and accretion.
Minus sign indicates landward movement and erosion.

APPENDIX G

SHORE STRUCTURES

1. Old Concrete and Timber Pile Breakwaters and Stone Groins at and North of Hampton Harbor Entrance. - Prior to construction of the present jetties at the Hampton Harbor entrance during 1934-1935, the Town of Hampton tried unsuccessfully to halt the erosion of the south end of Hampton Beach which accompanied the northward migration of the inlet by construction of breakwaters and groins. Two concrete breakwaters and a timber breakwater were built, reportedly after 1909. During 1932, the concrete breakwaters were in a state of ruin. Details concerning the structures are lacking. An inspection of the breakwaters around 1932 indicated that they were of unreinforced construction and failure occurred by undermining of their foundations. These structures are no longer visible. The ruins were apparently buried in the fill which was placed north of the north jetty during 1934-1935.

2. The timber pile breakwater consisted of two rows of untreated timber piling about 5 feet apart with the piles closely spaced in each row and tied together at the top by timber wales and cross bracing. When originally built, it projected only a few feet above the beach approximately parallel to the shore line, continuously from Haverhill Street to the inlet at Exeter Avenue. It is understood that it was intended to use this structure as a trestle from which to dump rock and that when complete, its effectiveness would depend upon the rock so placed. Only the trestle was built and during 1932 it stood generally seaward of the high water shore line with the piles 10 to 12 feet out of sand. Approximately 200 feet of the trestle between Bradford Street and Atlantic Avenue did not exist at this time. During 1932, three short low rock piles probably constructed as groins, existed behind the timber breakwater. These rock piles extended seaward in continuation of street ends. They reportedly caused some accretion, sand

having been observed frequently piled higher on their north sides. These rock piles were probably buried in the fill placed during 1934-1935. They were not visible during November 1952. The top of the timber pile breakwater south of Exeter Avenue was at about the level of the existing sand beach during November 1952. It projected about 1-1/2 feet above beach level at the bend in the structure opposite Exeter Avenue, this projection gradually increasing northward to about 7 feet north of Concord Avenue, and the northern section between Bradford and Haverhill Streets was 5 to 6-1/2 feet above beach level. Over 500 feet of the structure between Bradford Street and a point south of Boston Avenue did not exist during 1952. The timber in the existing structure appears to be in good condition, only slight deterioration being evident.

2. Existing Jetties and Sand Fill at Hampton Harbor Entrance. - The existing jetties at the Hampton Harbor entrance and the State bathing beach adjacent to the north jetty were constructed during 1934-1935 by the State of New Hampshire. The work accomplished was a modification of a plan recommended by the Beach Erosion Board in its report "Shore Protection at Hampton Beach, New Hampshire" dated July 15, 1932. The north jetty consisted of heavy stone averaging 6 tons in weight with a chip stone core varying between 1/2 and 2 feet in greatest dimension. It extended 450 feet westerly from Town Rocks. A sand dike was placed adjoining and extending 1,900 feet westerly and northerly into the harbor from the stone jetty. The channel face of the sand dike was paved with a 6-inch layer of gravel, a 12-inch layer of stone chips and a 2-foot layer of quarry stone, the latter averaging 3 tons each. The stone jetty had a 10-foot top width varying in elevation from 12 feet above mean low water at Town Rocks to 15 feet at the sand dike. The slope of the land face was 1 on 1 and the channel face was 1 on 2. The sand dike was built to an elevation of 15.0 feet above

mean low water with a slope of channel face of 1 on 2. The south jetty was constructed of heavy stone averaging 6 tons in weight without a core and it extended 1,800 feet westerly from White Rocks. A sand dike, 450 feet long was placed adjoining and west of the stone jetty. This dike extended into the harbor. The stone jetty had a top width of 10 feet at an elevation 6.0 feet above mean low water with side slopes of 1 on 2 on the channel side and 1 on 1 on the land side. The sand dike was built to a top elevation of 12 feet above mean low water. Paving on the channel side of the south dike was the same as for the north dike. The area between the top of the north dike and jetty and the 16-foot contour of the existing upland was filled with approximately 1,000,000 cubic yards of sand obtained from dredging a harbor of refuge and boat basin in Hampton Harbor. The fill reclaimed a 50-acre tract of land now used by the State of New Hampshire as a public bathing beach. The jetties and dikes confined the inlet to a 1,200-foot width. The work accomplished has successfully fixed the inlet thereby protecting the south end of Hampton Beach.

3. Old Shore Structures Fronting the Business Center. - The shore of Hampton Beach north of Haverhill Street was protected by various types of structures before construction of the existing sea wall during 1946-1947. A stone mound or breakwater was constructed during 1931 along the shore for about 900 feet north of Haverhill Street. Portions of the shore to the north were protected by light vertical-faced concrete walls except for a somewhat heavier concave-faced wall around the police station and a substantial timber bulkhead which projected out onto the beach at a playground north of the police station. The above structures were backfilled to the elevation of the boulevard to form promenade, play and parking areas. A northeast storm during April 21-22, 1940 demolished the light vertical-faced walls, displaced stones from the stone breakwater, washed out backfill and undermined and destroyed walks

and paved parking areas. Damages of this type were recurrent. Another storm in November 1945 undermined walks, eroded embankments, damaged walls, and eroded backfill material from the playground area behind the timber bulkhead.

4. Existing Sea Wall and Revetment Fronting the Business Center. - The inadequate shore structures fronting the business center were replaced by a new vertical-faced sea wall and riprap revetment by the State of New Hampshire during 1946-1947. The new construction was located in the area from Haverhill Street to a point between Nudd and Highland Avenues. The sea wall had a length of approximately 3,350 feet and it extended northward from a point just south of M Street. The riprap revetment was constructed south of the wall to Haverhill Street. Two types of wall were used. The northerly end, approximately 290 feet in length, consisted of a gravity section of concrete while the remainder was concrete encased steel sheet piling. The gravity section was used because of the existence of ledge rock near the surface which would not permit penetration of piling. The steel sheet piling was specified as Carnegie Section M112, Bethlehem Section SP4, or equivalent. Maximum length of piling was 18 feet driven so that it had a top elevation of 19.0 feet above mean low water. The piling was tied back by 1-1/2 inch steel rods to pairs of treated timber piles, 2 feet center to center, 20 feet long, cut off at elevation 17.58 feet above mean low water. The pairs of piles were driven vertically 18 feet landward of the steel sheet piling with a longitudinal spacing of pairs of 18 feet. Air entrained concrete was used for encasement of the upper portion of the piling as follows: encasement from a top elevation of wall of 19.50 feet above mean low water, 7-1/2 inches thick on each side of the longitudinal centerline of sheeting, 7-1/2 feet down on the seaward face, and 2-1/2 feet down on the landward face, with additional 3-inch thickness along the upper 16 inches of the seaward

face, making a total thickness of coping of 18 inches. The gravity section was built on ledge rock with the same top elevation coping thickness and appearance of seaward face as the adjoining concrete encased section. A batter of 12 on 7 was used on the landward face starting 20 inches down from the top of the wall. Steel reinforcing was used in the top and in the front face of the gravity section and throughout the concrete encasement over the piling. Steps leading down to the beach were provided at regular intervals along the wall. These steps were recessed behind the wall except near its center where the steps were built through the flanks of a bastion which projected about 10 feet out onto the beach. A walk approximately 22 feet wide was built landward of the sea wall, 8 feet of which adjacent to the wall being of concrete, the remaining 14 feet being of treated timber. This walk was constructed on a prepared base course. The riprap revetment south of the wall consisted of 1 foot of stone chips, 2 to 6 inches in diameter of assorted sizes of quarry grout on a 1-foot layer of gravel borrow, all overlain by a 2-1/2-foot layer of riprap, of which 75% was at least 1/2 cubic yard in size. The slope of riprap was 1 on 3 and it was laid to a top elevation of 19.0 feet above mean low water. The new construction is in excellent condition. It has adequately protected the parking, promenade, and play areas and the boulevard fronting the business section.

5. Shore Structures North of New Sea Wall Fronting the Business Center. - Details concerning the construction of shore protection works north of the above described sea wall fronting the business center to and around the tip of Great Boars Head are lacking. The following information was obtained by inspection of the area during November 1952. A vertical-faced concrete wall fronts Ocean Boulevard extending west and south of the drumlin at Great Boars Head. This wall is integral with and topped by a sidewalk, generally of concrete, although in places the

walk is surfaced with bituminous material. The walk is a continuation of the concrete walk existing behind the newer sea wall to the south. The wall extends southward to the vicinity of Ross Avenue. For about 100 feet south of Ross Avenue, the boulevard is fronted by dumped rip-rap revetment, no sea wall being evident. No shore structure was evident south of the revetment to the north end of the new sea wall. This latter area is characterized by numerous exposed bedrock outcrops which provide natural protection. Short sections of the concrete wall north of Ross Avenue are in a deteriorated condition. In a few places boulders and stones appear to have been placed at the toe of the wall to act as a revetment. Shore structures around the outer end and along the south side of Great Boars Head consist generally of concrete walls at the base of the steep-sloped drumlin. These walls extend around the tip of Great Boars Head and 200 feet along its north side. No protection has been provided along several hundred feet of the south side of Great Boars Head adjacent to Ocean Boulevard. The toe of portions of the drumlin in this area appeared newly eroded during November 1952 exposing glacial till containing a high percentage of gravel. The steep slope of the drumlin above its toe, however, was covered by thick vegetation. Adjacent to the east end of this unprotected shore area, concrete and rubble masonry walls protect the foundations of two buildings constructed on the slope of the drumlin near its base. These walls are in a deteriorated condition. About 60 feet of concrete wall and 40 feet of gravel and cobble revetment protect the toe of the drumlin adjacent to and east of the above buildings. East of the revetment for about 150 feet, the bluff is again unprotected. There was no evident erosion occurring in this area, the slope of the bluff being covered with vegetation. The next easterly 100 feet of toe of the bluff is protected by a concrete wall in a deteriorated condition and by a timber bulkhead. The remainder of the toe of the bluff to and around the outer tip of Great Boars Head is protected by a continuous series of concrete walls. The freshly exposed face of the toe of the bluff above these walls in places indicated recent erosion. Concrete toe walls exist in front of portions of the sea wall along the south face of the drumlin near its outer end. Portions of the older walls in this area were newly faced by a blanket of concrete. Sea walls around the outer tip of Great Boars Head reportedly require annual maintenance. Judging from the existence of thick vegetation over the slopes of the drumlin throughout most of its extent, erosion in recent years has been minor and confined to small areas along the toe of the slope.

APPENDIX H

ESTIMATES OF COSTS OF IMPROVEMENTS

1. Estimated Costs - Current Price Levels. - First costs and annual charges based on current price levels (as of March 1953) have been estimated for widening 5200 feet of beach north of Haverhill Street by direct placement of sand fill as shown on Plate 8. Annual charges have been computed based on Federal contribution of funds equal to one-third the estimated first cost of construction. The rate of interest on the Federal and non-Federal public investment has been computed as 2.5 percent. Amortization charges are based on a life of the project of 50 years. The maintenance requirement for the sand fill is based on average annual losses experienced between 1940 and 1952 landward of the 18-foot depth contour along that portion of shore to be filled.

a. First Costs

Sand fill, 340,000 cubic yards @ $1.00	$340,000
Engineering and contingencies	80,000
Total First Cost	$420,000

Allocation of Costs

Federal	$140,000
Non-Federal public	280,000

b. Federal Annual Charges

Interest	$ 3,500
Amortization	1,440
Total	$ 4,940

c. Non-Federal Public Annual Charges

Interest	$ 7,000
Amortization	2,870
Annual Maintenance 22,700 cu. yds. sand @ $1.00	22,700
Total	$32,570

d. Total Annual Charges $37,510

2. Estimates on Projected Price Level. - The estimates computed above are revised in accordance with applicable provisions of OCE letter dated 18 October 1951, subject "Proposed Practices for Economic Analysis", File ENGKW 800.12. Construction of the considered project is expected to occur within 5 years of the date of this analysis. Current prices are therefore used for the estimate of first costs. Maintenance costs will be incurred more than 5 years after this analysis. Long term projected prices are therefore used for maintenance costs based on a general price level approximately 10 percent below 1949. Projection is based on the Engineering News - Record Construction Index as follows:

		For 1939 = 100
ENR	Construction Index 1949	202.5
ENR	Long Term Projection	180
		For 1913 = 100
ENR	Construction Index March 1953	587.4
ENR	Construction Index March 1949	477.0
ENR	Long Term Projection $= \frac{477 \times 180}{202.5} =$	424.0

Projected maintenance costs $= \frac{424}{587.4}$ x Current costs = 0.72 x Current costs

Final revised costs are therefore as follows:

a. First Costs (No change)

Sand Fill, 340,000 cubic yards @ $1.00	$340,000
Engineering and contingencies	80,000
Total First Cost	$420,000
Allocation of Costs (No change)	
Federal	$140,000
Non-Federal Public	280,000

b. Federal Annual Charges (No change)

Interest	$3,500
Amortization	1,440
Total	$4,940

c. Non-Federal Public Annual Charges (Revised)

Interest	$7,000
Amortization	2,870
Annual Maintenance	
22,700 cu. yds. sand @ $0.72	16,344
Total	$26,214

d. Total Annual Charges $31,154

APPENDIX I

ECONOMIC DATA

1. Basic Data. - Economic data regarding Hampton Beach were furnished by the Governor of the State of New Hampshire and by several state agencies. The following are attached as Exhibits 1, 2 and 3.

Exhibit 1. Letter from Governor of State of New Hampshire dated June 4, 1953.

Exhibit 2. "The Significance of Hampton Beach as a Recreation Center," May 27, 1953. Recreation Division, New Hampshire Forestry and Recreation Department, Russell B. Tobey, Director. (submitted as an inclosure to Exhibit 1.)

Exhibit 3. "Memorandum on the Economic Importance of Hampton Beach" May 1953. Andrew M. Heath, Research Director, New Hampshire State Planning and Development Commission.

Other data were furnished by the New Hampshire Department of Public Works and Highways. Significant information not included in Exhibits 1, 2 and 3 is listed below.

a. Beach Use

State Bathhouse Near Hampton River.

Checking facilities	5,000 units
Average daily attendance, 1952	1,000 persons
Peak attendance, 1952	5,000 persons
Total attendance, 1951 season	68,020 persons
Total attendance, 1952 season	83,614 persons

b. Parking Facilities

State lot near Hampton River.

Capacity	1,000 cars
Average daily use	300 cars
Peak use	1,000 cars

Other parking lots (state and municipal)

Capacity	1,550 cars
Use	Reported usually filled to capacity during summer season

Street parking

Capacity	4,250 cars (Police Dept. Estimate)
Use	Usually filled to capacity

c. Hotels, Inns, Cabins, Motels - Accommodations

Capacity	10,000 persons (estimated by Planning and Development Commission and estimate agreed to by Chamber of Commerce).
Use	During summer season, accommodations are practically always filled.

d. Total Beach Accommodations

According to a leading real estate agent, there are approximately 22,000 beds in the Hampton Beach precinct.

e. Public Transportation Service to Hampton Beach

System	No. Passengers (Summer)
Massachusetts Northeastern Transportation Company, Haverhill, Massachusetts	20,000 per week average 30,000 during peak week 6,000 during peak day
Boston & Maine Transportation Company, Boston, Massachusetts	Company states they do a tremendous summer business. to Hampton Beach. No records on volume available.

NOTE: Hampton Beach is served by other transportation systems not listed above since no information regarding volume of traffic is available.

f. Vehicle Traffic Counts. - Data on vehicle traffic counts on the principal direct approaches to Hampton Beach were furnished by the New Hampshire Department of Public Works and Highways. These counts were taken on the Hampton River Toll Bridge, on Route NH 1A at Little Boars Head in North Hampton and on Route NH 101E, the main road between Hampton Village and Hampton Beach. Other counts on principal north-south highways (U. S. Route 1 and the New Hampshire Turnpike) and the east-west highway, NH Route 101C were also furnished. Average recorded traffic figures on the direct approaches to Hampton Beach are summarized below.

Location. - Hampton River Toll Bridge

Period of Record - July - August 1952

Average Through Traffic - Number Vehicles

Sunday	11,245
Saturday	10,563
Weekday	6,803
Holiday (July 4 & 5)	16,001

Location. - Route NH 101E between Hampton Village and Hampton Beach.

Period of Record. - July 18-24, 1952

Average Through Traffic. - Number Vehicles

Sunday	12,958
Saturday	11,655
Weekday	7,746

Location. - Route NH 1A at Little Boars Head

Period of Record. - June 29 - August 30, 1952

Average Through Traffic - Number Vehicles

Sunday	7,193
Saturday	5,649
Weekday	4,725
Holiday (July 4 & 5)	7,810

EXHIBIT 1

Letter from Governor of State of New Hampshire

June 4, 1953

Col. L. H. Hewitt
Division Engineer
Corps of Engineers
857 Commonwealth Avenue
Boston 15, Massachusetts

Dear Colonel Hewitt:

I am transmitting to you, herewith, a report prepared by my Recreation Division on the significance of Hampton Beach as a Recreational Center. I concur in the statements made in this report but believe one additional fact might be noted.

We have, as you know, a sea wall project under consideration in our Legislature. Incident to this sea wall there will be provision for a material increase in off-street parking. From this parking facility it has been estimated that an annual revenue in the amount of $37,877 will be obtainable which can be applied to the amortization of the sea wall project. This is merely one example of a definite benefit whose actual dollar value can be computed with some considerable accuracy.

My department of Public Works and Highways has also pointed out to me that if continued erosion of the sand from Hampton Beach is permitted, the existing sea wall and highway will be placed in serious jeopardy. In view of this condition it would not seem advisable to undertake the construction of additional sea wall and highway facilities without first providing some safeguard for the retention of facilities that already exist in this area.

It, therefore, appears to me that the economic benefits that will accrue from the project should not be entirely measured from a recreational viewpoint. Continued erosion of the beach will also cause serious economic losses through damage to existing and proposed facilities covered by the expenditure of public funds in the form of sea walls, highways, and buildings.

Sincerely,

/s/ Hugh Gregg
Hugh Gregg

HG/ejc
Enc.

EXHIBIT 2

NEW HAMPSHIRE FORESTRY AND RECREATION DEPARTMENT

RECREATION DIVISION RUSSELL B. TOBEY, DIRECTOR

May 27, 1953

THE SIGNIFICANCE OF HAMPTON BEACH AS A RECREATIONAL CENTER

Hampton, N.H., a town with a population of 2,847, is located in the southeastern corner of the state bordering the Atlantic Ocean. Within a radius of approximately fifty miles live approximately 2,350,000 people.

Hampton Beach, some two miles from the town's center, is the only commercial beach on New Hampshire's eighteen miles of coast line. The main section of the beach is some over a mile in length and at mean low tide presents an arc of sand varying in width from approximately 300 feet to 0 feet within approximately three quarters of this length. This is in distinct contrast to conditions which prevailed in the 1920's and 1930's when the width of the beach averaged from 150-200 feet for nearly nine-tenths of its length.

The resort and commercial area adjacent to this beach comprise approximately 574 acres and has a town precinct status. The evaluation of property in this precinct for 1952 was $5,252,055, slightly over one-half the total evaluation for the town of Hampton.

The drift of sand in a southerly direction has been obvious to sight and presents a serious deterioration to the prime recreational asset of this resort area. These natural drifts and shifts of sand have further hampered the economy of the community by choking the mouth of the Hampton River and filling in Hampton Harbor, reducing the capacity of the harbor considerably in a few years' time and presenting extreme hazards to boat passage at the river mouth. That these changes have had a deteriorating effect upon the economy of this, New Hampshire's largest beach resort area, is demonstrable from economic data.

Analysis of available data indicates that if the recreational facilities of Hampton Beach are to serve and derive benefit from the growing needs of a wide geographical area, its beach and harbor must be restored.

The most rapidly growing section of New Hampshire since World War II has been the seacoast region. About half of the recreation property valuation in this region, $6 million out of $12, is located at Hampton Beach. This valuation of recreation property exceeds that of any other town in the state.

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In spite of the erosion of the beach and the filling of the harbor, recreation business at Hampton has increased steadily from year to year. With the completion of the N.H.-Maine turnpike in 1951, traffic over the Hampton Harbor toll bridge increased 50%. The linking of the southern end of that turnpike next year by superhighway to the Boston Circumferential system at Danvers may be expected to produce similar effects.

Hampton Beach is strategically situated to serve the recreation needs of not only such industrial southern New Hampshire towns as Manchester and Nashua, but also eastern Massachusetts with Boston only 48 miles away and the industrial belt of Connecticut soon to be linked all the way by superhighway. Ownership of seasonal residences at Hampton Beach discloses the wide geographical area served. Fifty-six percent are owned by Massachusetts residents, two percent by New York residents and three percent by residents of eleven other states and D. C. Three thousand one hundred and ninety-seven keyed inquiries in response to newspaper advertising of the Hampton Beach Chamber of Commerce in 1952 throw further light on the source of Hampton's recreation business. Thirty-five percent of the inquiries came from Massachusetts, 33% from Eastern Canada, 13% from Connecticut and 11% from up-state New York.

Some idea of the size of this business can be obtained by considering the following facts:

Total year-round payroll earnings in private establishments as reported by the State Employment Security Division have changed little between 1947 and 1952; $813,219 in the former year and $858,358 in the latter. However, seasonal earnings reported by the same agency have increased by over 50% during the same period, from $221,486 to $333,558. Sixty-six percent of the customers of the Hampton Water-Works Company are seasonal. Of 3,323 electricity meters in Hampton and Hampton Beach, 723 are shut off during the winter. Last year, 79% of Hampton Post Office revenue was collected from the Beach Station, which is open from May 1 to September 30. Most of the retail trade at the Beach is conducted during the summer and at Hampton, which is some two miles inland, a survey disclosed that 30% to 50% of annual retail trade is transacted during July and August. At a meeting of Hampton selectmen, Hampton Beach precinct commissioners and Chamber of Commerce representatives on May 20, 1953, it was agreed that $10,000,000 would be a conservative estimate of the annual volume of recreation business.

Some idea of the growth of the area and the rising significance of recreation can be gained by noting that total assessed valuations have risen from $6,029,275 in 1945 to $10,029,899 in 1952. In 1945, 54% of the total value was recreation property and by last year this had risen to 61.4%. The Exeter and Hampton Electric Company reports a gain of 155.19% in kw-hours, sold in the area over the same period. The records of the Allied New Hampshire Gas Company show an increase of consumption in the area of 5% to 8% each year. The Post Office reports an overall increase in business from 1945 to 1952 of 34%. The receipts of the Hampton Beach State Park, which consist of parking area and bathhouse fees and sales of foodstuffs, have increased by 64% from 1947 to 1952.

Hampton Beach serves primarily that most rapidly growing section of the U. S. population, the middle-income groups. This is demonstrated by the fact that the greatest increase in property valuations has been in tourist cabins and motels, an increase of 787% since 1945. The seasonal residences are also of the type appealing to the middle-income groups with an average assessed valuation of $2,069 in 1945 and $2,229 in 1952.

If Hampton Beach is to continue to meet the growing recreation needs of these middle-income vacationers in New England and the northern seaboard, its recreation capacity must not only be preserved but increased. The present intensive utilization of the beach is illustrated by the results of a census which was made on an August Sunday afternoon last year. Some 46,000 people were counted on the sands and in the water. On the main beach itself there were 34,689 people, which works out to about one person per 12 square feet. This is a matter of concern to the health and recreational authorities of New Hampshire since 25 square feet per person is considered the minimum standard. The unique problem of Hampton Beach is that whereas the demands to use it are increasing, the beach itself is decreasing.

To serve the growing interest in boating and fishing, accretion in the harbor must be removed. Two types of commerce in Hampton Harbor are seriously affected by the filling and deterioration of navigational and mooring conditions. Although the number of commercial lobster boats has shown a slight increase since 1949, the gross yearly business of around $100,000 remains unchanged. An increase has occurred in the number of people patronizing deep sea fishing and as well the number of party boats serving them. It is estimated that the dollar value of this business has grown by roughly one third since 1949 so that it now approximates $100,000 each season. However, due to the silting and dangerous navigational conditions, there is a definite limit to any further expansion. Indeed, even maintaining the status quo is problematical.

There is a third type of business which the deterioration of the harbor has virtually eliminated. Prior to 1947, an average of 100 transient cruising parties visited the harbor seasonally. Now there are only two or three such parties a year, and they come only to seek needed refuge from high seas and storms. Thus yachtsmen in north Atlantic waters have been deprived of the use of this harbor and Hampton is deprived of the summer spending of this class of vacationer, and further the year-round revenue from boat service storage and repairs. This condition not only deprives the town of taxable property for lack of seasonal storage, but denies the growth of private boat service business.

If it proved feasible to restore the beach with fill removed from the harbor, the capacity of both to serve recreation needs would be greatly increased.

The volume and growth of the recreation business at Hampton Beach as revealed by the available data make it evident that more than a local need is met. Its strategic location relative to great centers of population and improved highway systems promise further expansion. Even to maintain its present services, let alone to accommodate a foreseeable continued growth, it would seem to be indicated that its natural facilities must be restored.

EXHIBIT 3

MAY 1953

MEMORANDUM ON THE ECONOMIC IMPORTANCE OF HAMPTON BEACH

By: Andrew M. Heath, Research Director,
N.H. State Planning & Development Commission

Hampton Beach is by far the greatest resort center in New Hampshire, which is widely known as a vacation state. While vacation business is second only to manufacturing in the economy of New Hampshire, it is paramount in the Hampton area.

The expenditures of vacation visitors are the base for the major portion of local property tax revenue, supporting local government, schools, and roads. They provide the principal business and employment opportunities in the town, attracting investment from Massachusetts and other states as well as New Hampshire. Summer cottages in Hampton are owned by residents of 14 states and the District of Columbia.

Expansion of the vacation business at Hampton Beach has been rapid in recent years, and the area has become increasingly dependent upon this source of income.

The broad, sandy beach is the prime attraction for many, many thousands of people. Continued existence of the important economic structure which has sprung from this attraction obviously depends upon the continued existence of the beach itself; much of which has been washed into the sea.

Evidence to support the above statements is given in two surveys of recreation property, made in 1945 and in 1952 by the State Planning and Development Commission. The figures below are from those surveys.

NUMBER OF RECREATION PROPERTIES IN HAMPTON

	1945	1952	Increases	% Increase
Seasonal Residences	1,166	1,741	575	49
Hotels and Inns	72	87	15	21
Cabins and Motels	10	53	43	430
Other (1952 only)		37		

VALUATION OF RECREATION PROPERTY IN HAMPTON

	1945	1952	Increase	% Increase
Seasonal Residences	$2,407,150	$3,881,050	$1,473,900	61
Hotels and Inns	753,000	994,550	241,550	32
Cabins and Motels	78,200	693,400	615,200	787
Comparable totals	$3,238,350	$5,569,000	$2,330,650	72*
		592,620		
		$6,161,620		

* Non-recreation property valuation increased only 41% in the same period.

VALUATION OF RECREATION PROPERTY AND ALL PROPERTY IN HAMPTON

		% of Total
Total Property Valuation 1952	$10,029,899	100.0
Recreation Property Val. 1952	6,161,620	61.4

OWNERSHIP BY STATE OF OWNER'S RESIDENCE

	Number	% of Total	
SEASONAL RESIDENCES			
Massachusetts	971	56%	55.77
New Hampshire	696	40	39.98
New York	30	2	1.72
11 other States & D. C.	44	3	2.53
	1,741	100%	
HOTELS AND INNS			
New Hampshire	65	75%	[illegible]
Massachusetts	20	23	[illegible]
Other	2	3	2.30
	87	100%	
CABINS AND MOTELS			
New Hampshire	40	75%	
Massachusetts	12	23	
Other	1	2	
	53	100%	
OTHER COMMERCIAL PROPERTIES			
New Hampshire	26	70%	
Massachusetts	10	27	
Other	1	3	
	37	100%	

APPENDIX J

ESTIMATES OF BENEFITS FROM IMPROVEMENTS

1. General. - All evaluated benefits from restoration, protection and improvement of the beach are based on prevention of losses of beach material, prevention of damages now occurring to the existing sea wall, sidewalk and shore road, on the promotion and encouragement of the healthful recreation of the people and on the increased earning power of recreational properties. Other monetary benefits, not readily evaluated, will also result. These benefits include prevention of anticipated direct damages to existing and proposed facilities such as sea walls, highways, parking areas and buildings which will be endangered by continued erosion. Other unevaluated benefits include increased value of recreational property and prevention of loss of existing business returns. The United States is not a land owner in the area so no Federal benefit will result. All evaluated benefits are non-Federal public or private. The nature of non-evaluated benefits are indicated by available economic data (See Paragraph 4 of this Appendix).

2. Evaluated Benefits - Current Price Levels.

a. Non-Federal Public

(1) Direct Damages Prevented. - Since 1940 the State of New Hampshire has placed an average of 704 cubic yards of sand fill per year on the beach. The average cost of the most recent fill placement was $1.00 per cubic yard. Annual benefit from elimination of this expenditure is estimated on current price levels as 704 x $1.00 or $704. Actual expenditures for repairs to the sea wall, walk and cleaning up of storm debris along the shore boulevard during the period 1940-1952 inclusive amounted to $49,656.52 or approximately $3,820 per year. The proposed sand fill will provide a

protective beach which will prevent such damages thereby resulting in a benefit estimated as $3,820 per year (on 1940-1952 price levels). Conversion of this benefit to a current price level is computed as follows:

ENR Construction Index, Average for 1940-1952	=	383.8
ENR Construction Index, March 1953	=	587.4
Current benefit = $\frac{587.4}{383.8}$ x $3820	=	$5846

(2) Recreational. - The area of sand beach available for recreational use is inadequate during periods of peak use resulting in extreme overcrowding. Erosion of sand north of Haverhill Street is resulting in a gradual loss of beach area and deterioration of the beach composition. There has been a large increase in the development and use of Hampton Beach during recent years. It is expected that highway and beach developments now planned for the near future will result in further increase in beach use. The increasing beach use combined with decreasing beach area is intensifying the problem of accommodating beach patrons. The capacity of the beach based on a desirable space standard of 75 square feet per person for all usable areas above the high water line is as follows:

Between Hampton River and Haverhill Street	- 9,400 persons
Between Haverhill Street and Great Boars Head	- 3,800 persons
Total	13,200 persons

A record of beach attendance is available for only one Sunday during August 1952 when a count showed that there were 34,689 people on the sand and in the water in the beach area between Hampton River and Great Boars Head. The proposed project will increase the capacity of the beach north of Haverhill Street so as to accommodate an additional 6,600 persons. This portion of the beach fronts the business section which contains the shops, restaurants, the principal hotels, the bandstand, the boardwalk or what may be generally termed the center of activity at the beach. It therefore attracts a much higher proportion of the public than adjacent areas located farther away. The proposed project will therefore provide additional beach area where it is needed most. The recreational benefit from the provision of needed space is computed as follows:

Length of bathing season (assumed)	10 weeks
Period suitable for bathing because of weather conditions (assumed)	7 weeks
Estimated number of days when full benefit will be derived from the additional beach area (Sundays, Saturdays and one holiday)	15
Capacity of additional beach area	6,600 persons
Number of additional per capita beach uses 15 x 6600	99,000 persons

The monetary benefit from the improvement of beach space standards is computed on the basis of per capita use of the additional space provided by assigning a value to per capita use equal to an estimated charge which would be assessed if the beach were a private enterprise. This charge is estimated as $0.25 per capita. The annual monetary recreational benefit on current price levels therefore becomes,

$$\$0.25 \times 99{,}000 = \$24{,}750$$

<u>b</u>. <u>Private</u>

(1) <u>Increased Earning Power</u>. - The proposed fill by relieving congestion and improving the beach composition will make Hampton Beach more attractive to patrons. It is estimated that beach patronage will be increased at least 10% of which one-half or 5% will consist of daily visitors and the other 5% of summer resident visitors. Increased patronage will result in an estimated 10% increase in business returns for commercial places such as restaurants, shops, bowling alleys, etc. The

increased patronage will result in an estimated 5% increase in income for hotels, inns, cabins, motels and seasonal residences. The gain involved may be evaluated in terms of increased rentals of all recreational properties, actual or possible, for business or residential purposes. Assuming the annual rental to be 12 percent of the assessed valuation, benefits are evaluated as follows:

Commercial Places (Restaurants, shops, etc.)

Assessed value (1952)	$592,620
Estimated benefit = 0.10 x 0.12 x $592,620 =	$7,110

Hotels, Inns, Cabins, Motels, Seasonal Residences

Assessed value (1952)	$5,569,000
Estimated benefit = 0.05 x 0.12 x $5,569,000 =	$33,410
Total Increased Earning Power	$40,520

Summary of Benefits - Current Price Levels

Benefit	Non-Federal Public	Private	Total
Direct Damages Prevented	$ 6,550	-	$ 6,550
Recreational	24,750	-	24,750
Increased Earning Power	-	$40,520	40,520
Total	$31,300	$40,520	$71,820

3. Estimates on Projected Price Level. - The estimates of benefits computed in the preceding paragraph are revised in accordance with applicable provisions of OCE letter dated 18 October 1951, subject "Proposed Practices for Economic Analysis", File ENGKW 800.12. Long term projections are used for all benefits. Benefits computed above on current price levels are projected in accordance with formula in Paragraph 2 of Appendix H whereby

Projected benefits = 0.72 x current benefits

Projection of benefits is made as follows:

a. Non-Federal Public Benefits

(1) Direct Damages Prevented

$6,550 x 0.72 = $ 4,716

(2) Recreational

$24,750 x 0.72 = $17,820

b. Private

(1) Increased Earning Power

$40,520 x 0.72 = $29,174

Summary of Benefits - Projected Price Level

Benefit	Non-Federal Public	Private	Total
Direct Damages Prevented	$4,716	-	$ 4,716
Recreational	17,820	-	17,820
Increased Earning Power	-	$29,174	29,174
Total	$22,536	$29,174	$51,710

4. Benefits Not Evaluated

a. Non-Federal Public

(1) Direct Damages Prevented. - Continuation of the present process of erosion and loss of beach material can result in narrowing of the beach thereby increasing the vulnerability of the existing sea wall, adjacent public buildings and parking areas, walk and shore road to damages from wave attack. Damages can increase in areas already exposed to wave attack and can eventually occur in areas now protected by the existing sand beach. The State Legislature has approved construction of a new sea wall and additional off-street parking areas along the north end of Hampton Beach. The Legislature, recognizing the need for beach protection for the above work, has made appropriation of funds contingent upon adoption by the United States of a project for such protection. The project considered in this study can provide protection of the type needed.

b. Private

(1) Increased Earning Power or Value of Recreation Property. - The 1952 valuation of recreation property in the Town of Hampton was \$6,161,620 or 61.4% of the total town evaluation. The principal recreational attraction is the bathing beach. The restoration, protection and improvement of the beach can result in an increase in the value of the recreation property which is dependent on it. The annual volume of recreation business at Hampton Beach has been estimated as \$10,000,000. Loss or deterioration of the bathing beach can result in a decrease in the earning power of the above business. The magnitude of the valuation of recreational property and the volume of recreation business indicates that substantial private benefits will be derived from the project considered.

5. Adjusted Benefits. - Adjusted benefits are computed in accordance with OCE letter dated 21 July 1953, subject, "Proposed Practices for Economic Analysis", File ENGKW 800.12 whereby

Adjusted benefits = Current benefits x (1-(Pc-Pb)) in which Pc is the ratio of estimated project costs on a projected price basis to the estimated project costs on a current price basis and Pb is the ratio of projected benefit values to current benefit values.

$$Pc = \frac{31{,}154 \text{ (from App. H, Par. 2)}}{37{,}510 \text{ (from App. H. Par. 1)}}$$

$$= 0.83$$

$$Pb = \frac{51{,}710 \text{ (from App. J, Par. 3)}}{71{,}820 \text{ (from App. J, Par. 2)}}$$

$$= 0.72$$

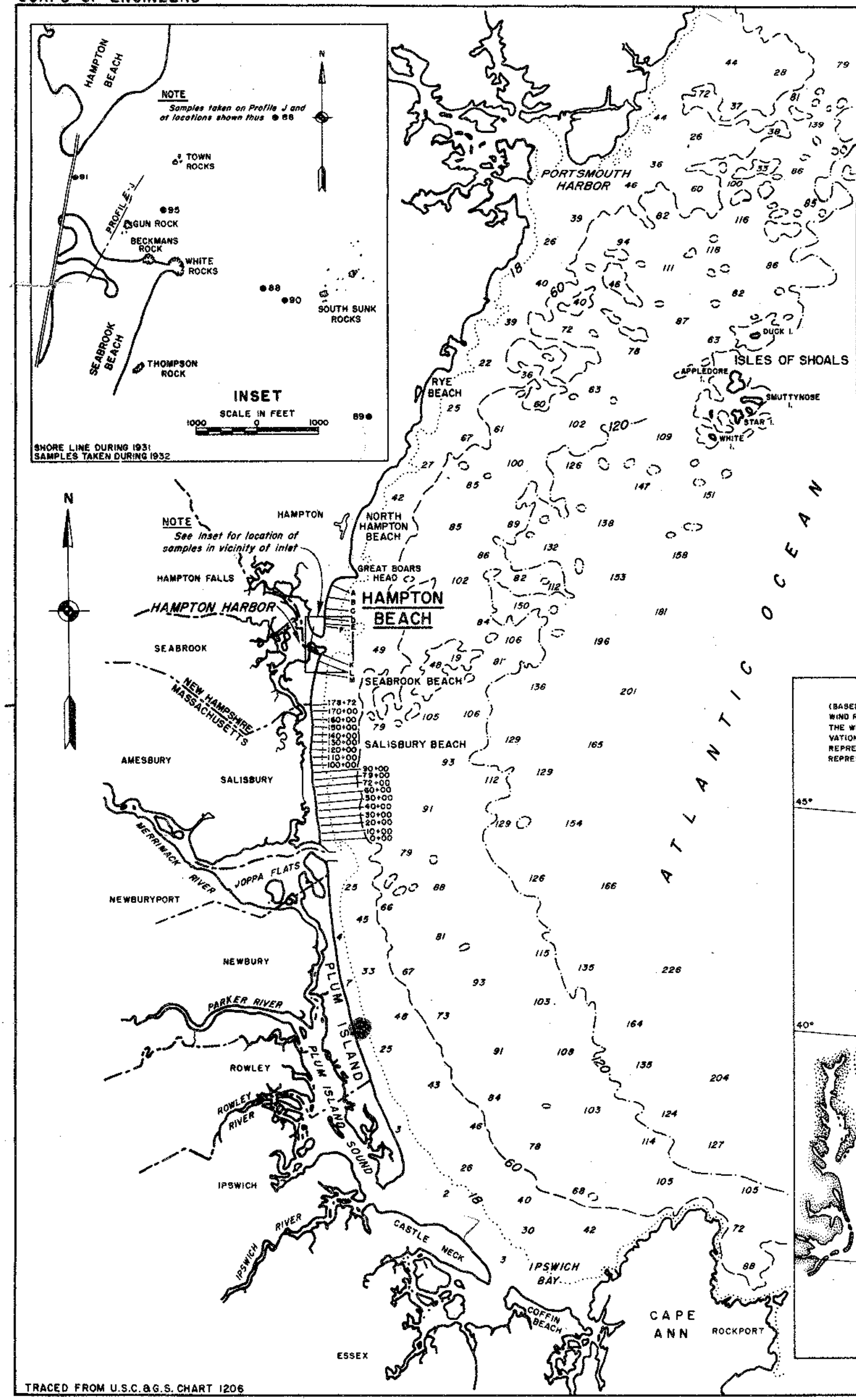
Adjusted Benefits = Current benefits x (1-(0.83-0.72))

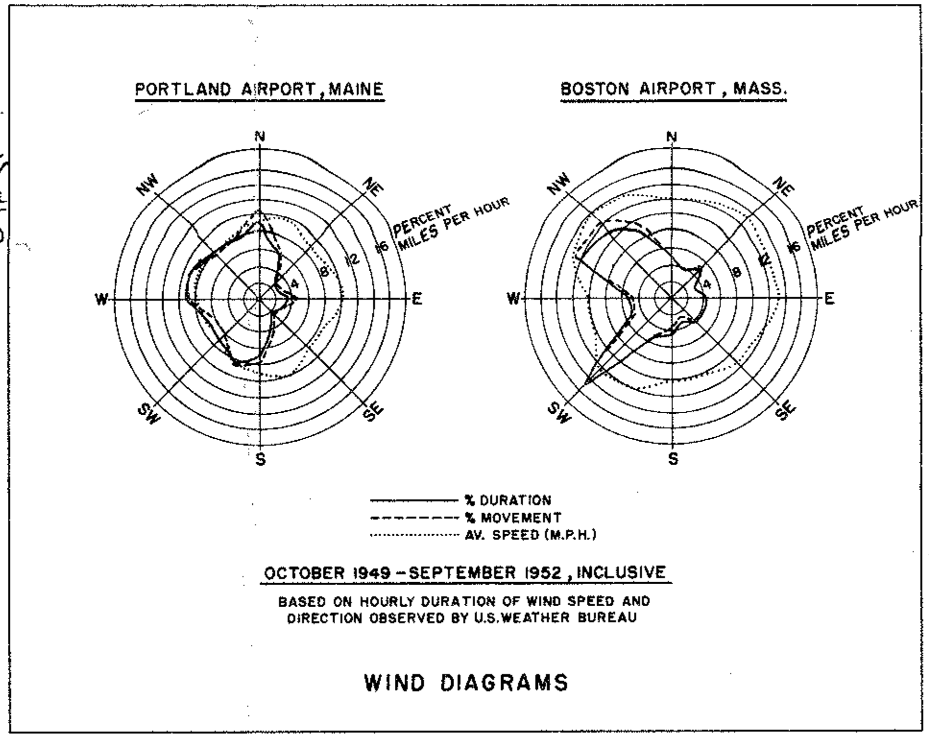
= Current benefits x (0.89)

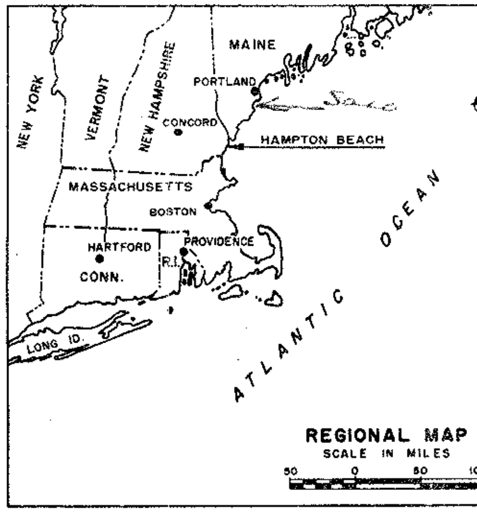
Summary of Adjusted Benefits

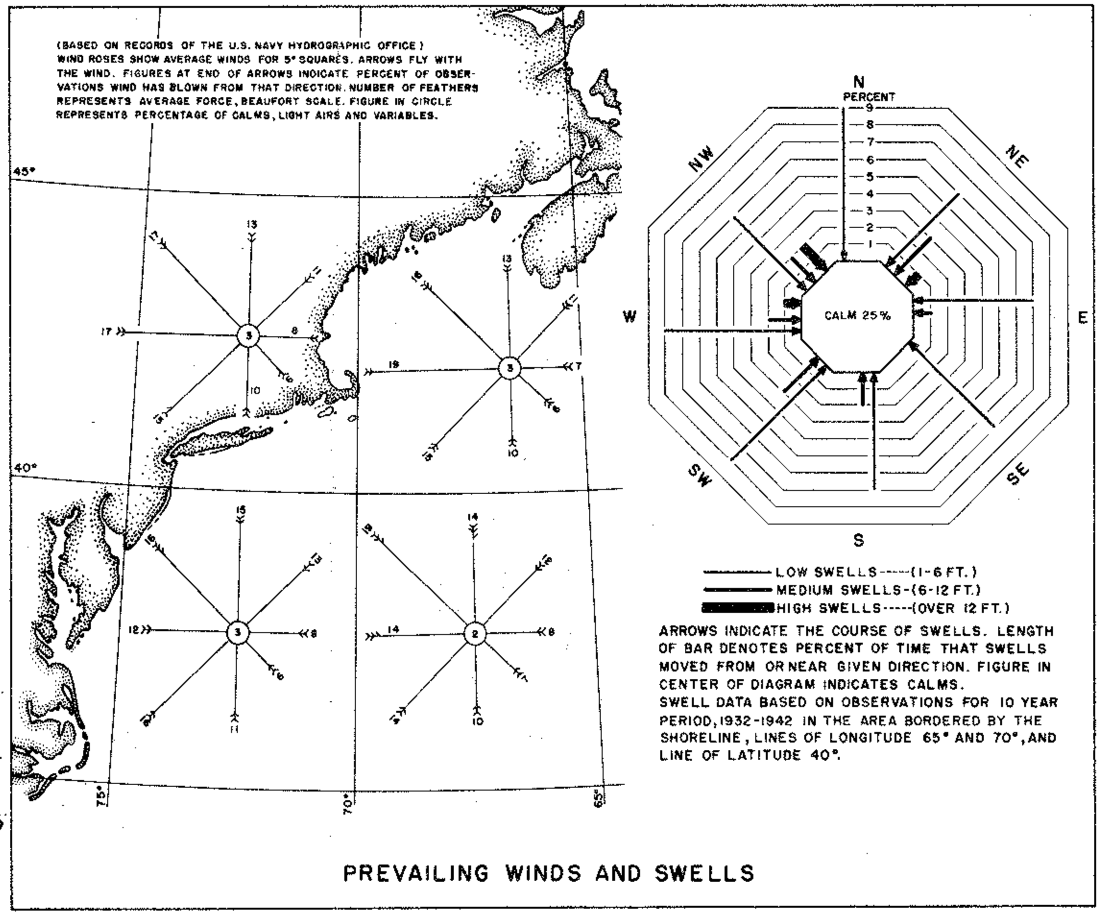
Benefit	Non-Federal Public	Private	Total
Direct Damages Prevented	$ 5,830	-	$ 5,830
Recreational	22,030	-	22,030
Increased Earning Power	—	36,060	36,060
Total	$27,860	$36,060	$63,920

CORPS OF ENGINEERS









NOTES

Locations of profiles on which beach and offshore samples were taken during prior investigations shown thus:

SHORE LINE — 8 — 10+00

For samples taken for this study during 1952, see Plate 8.

BEACH EROSION CONTROL STUDY OF HAMPTON BEACH, NEW HAMPSHIRE

GENERAL MAP

IN 1 SHEET — SCALE IN FEET 5000 0 10000 20000

NEW ENGLAND DIVISION, BOSTON, MASS. JAN. 7, 1953

APPROVED: CHIEF, ENGINEERING DIVISION

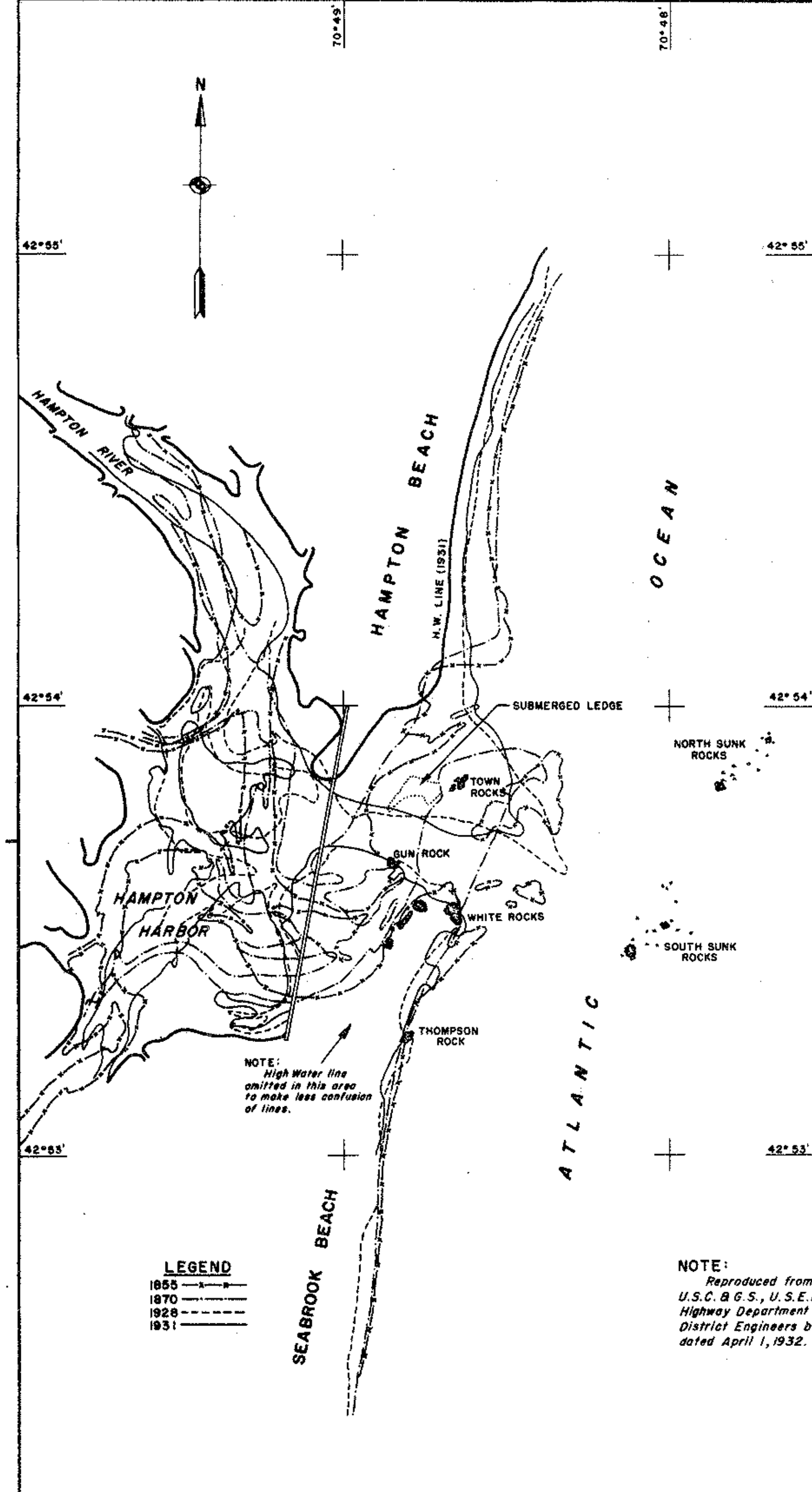
APPROVED: COL. C.E. DIVISION ENGINEER

SUBMITTED: CHIEF, PLANNING AND REPORTS BRANCH

TRANSMITTED WITH REPORT DATED: AUG. 14, 1953

F. W. Fogarty — CHIEF, RIVER AND HARBOR SECT.

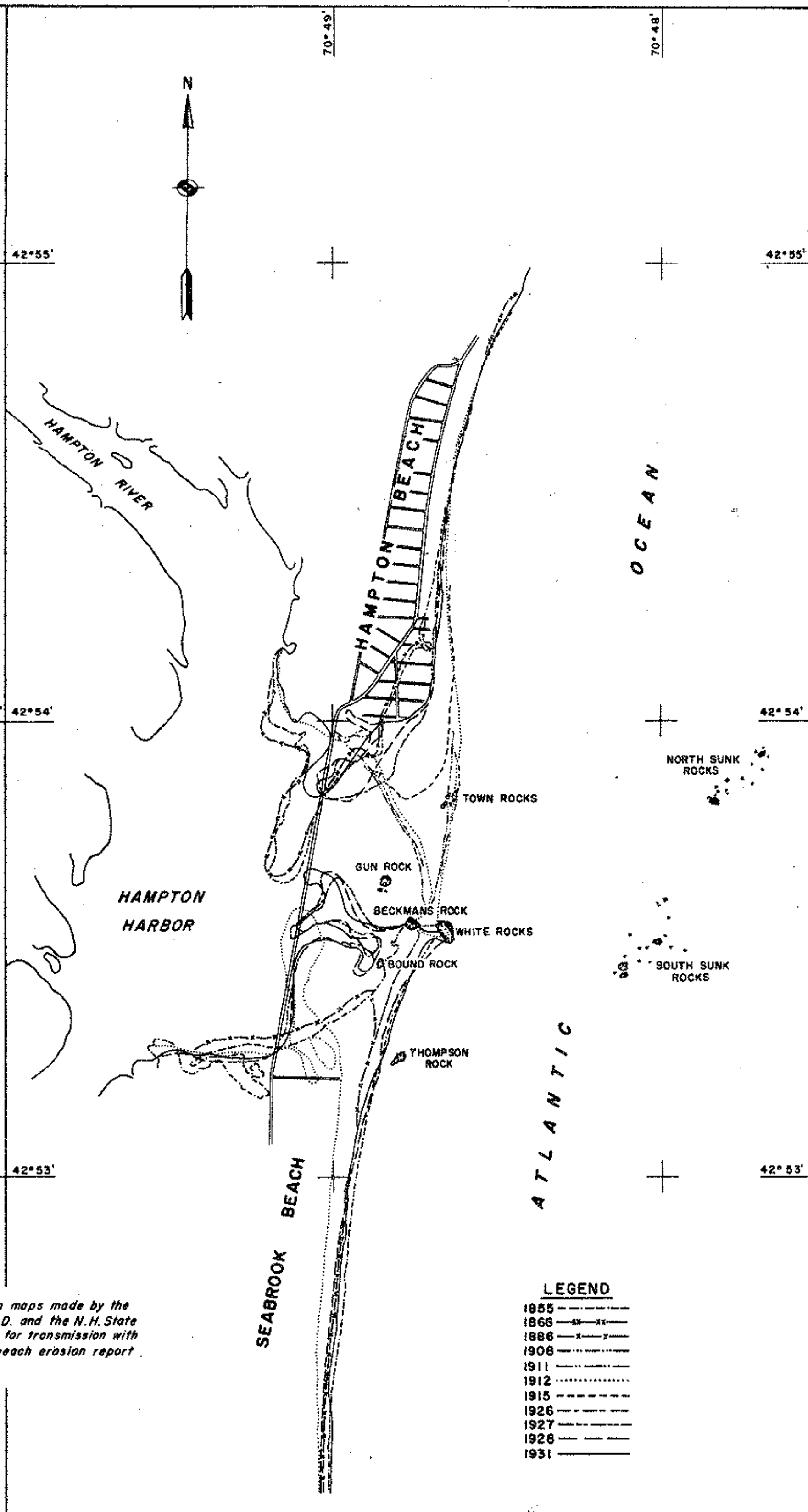
FILE NO. 8.E. Hn. 1



CHANGES IN LOW WATER LINE 1855-1931

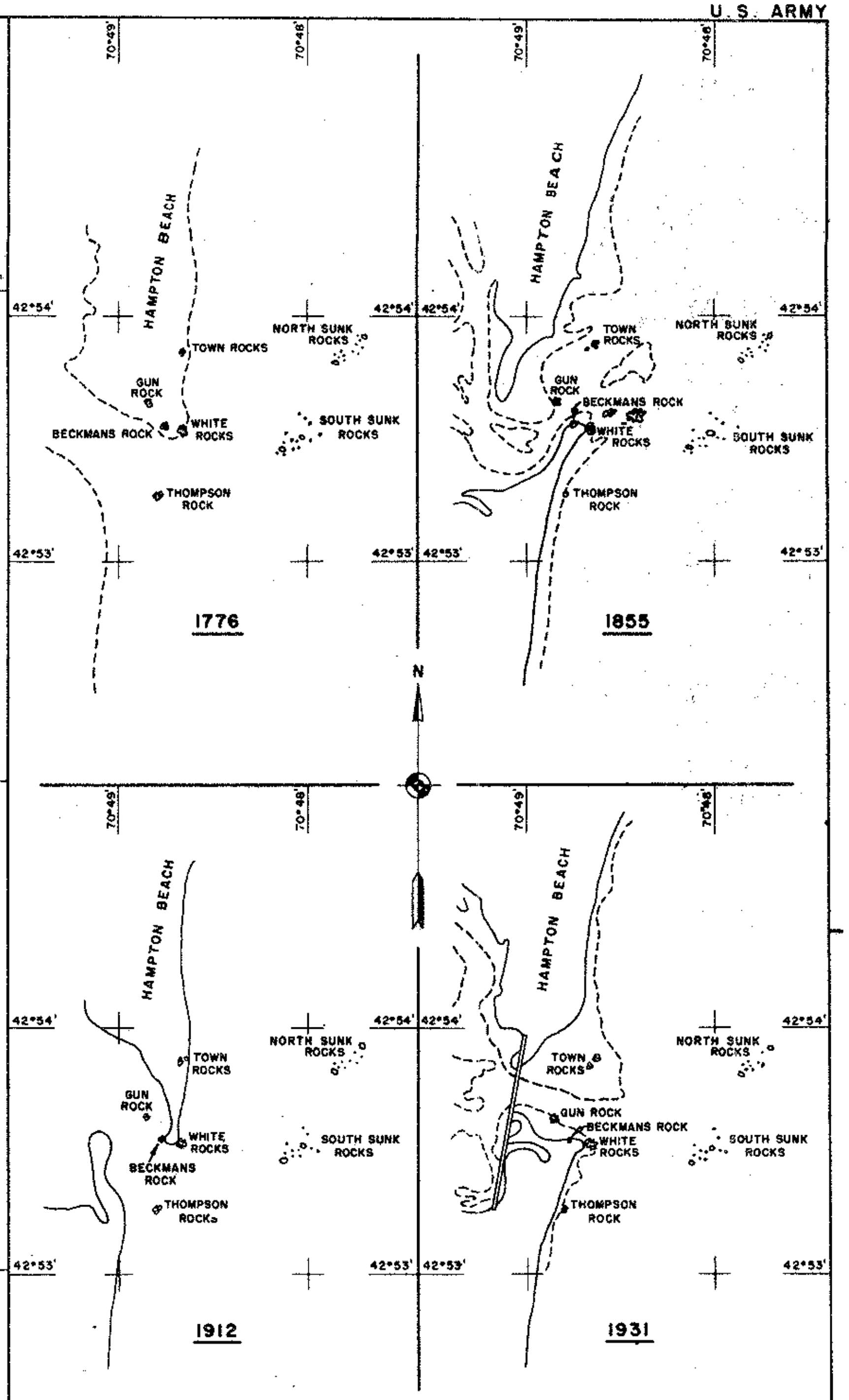
SCALE IN FEET
1000 0 1000 2000

NOTE:
Reproduced from maps made by the U.S.C. & G.S., U.S.E.D. and the N.H. State Highway Department for transmission with District Engineers beach erosion report dated April 1, 1932.



CHANGES IN HIGH WATER LINE 1855-1931

SCALE IN FEET
1000 0 1000 2000



SHORE LINE CHANGES 1776-1931

APPROXIMATE SCALE IN FEET
2000 0 2000 4000

NOTE:
Shore line of 1776 from British Admiralty charts. Other shore lines from U.S.C. & G.S. charts, U.S.E.D. maps and maps of N.H. State Highway Department.
Traced from enlargement of Plate I of Beach Erosion Board's report dated July 15, 1932.

LEGEND
H.W. SHORELINE ———
L.W. SHORELINE - - - -

BEACH EROSION CONTROL STUDY OF HAMPTON BEACH, NEW HAMPSHIRE

SHORE LINE CHANGES

IN 1 SHEET SCALES AS SHOWN

NEW ENGLAND DIVISION, BOSTON, MASS. JAN. 2, 1953

APPROVED: J. E. Allen — CHIEF, ENGINEERING DIVISION
APPROVED: [signature] — COL. C.E. DIVISION ENGINEER
SUBMITTED: [signature] — CHIEF, PLANNING AND REPORTS BRANCH
TRANSMITTED WITH REPORT DATED: AUG. 14, 1953
F. W. Fogarty — CHIEF, RIVER AND HARBOR SECT.
DR. BY: A.L.O. TR. BY: A.L.O. CK. BY: [initials]
FILE NO. B.E. Hn. 2

WAR DEPARTMENT

CORPS OF ENGINEERS, U.S. ARMY

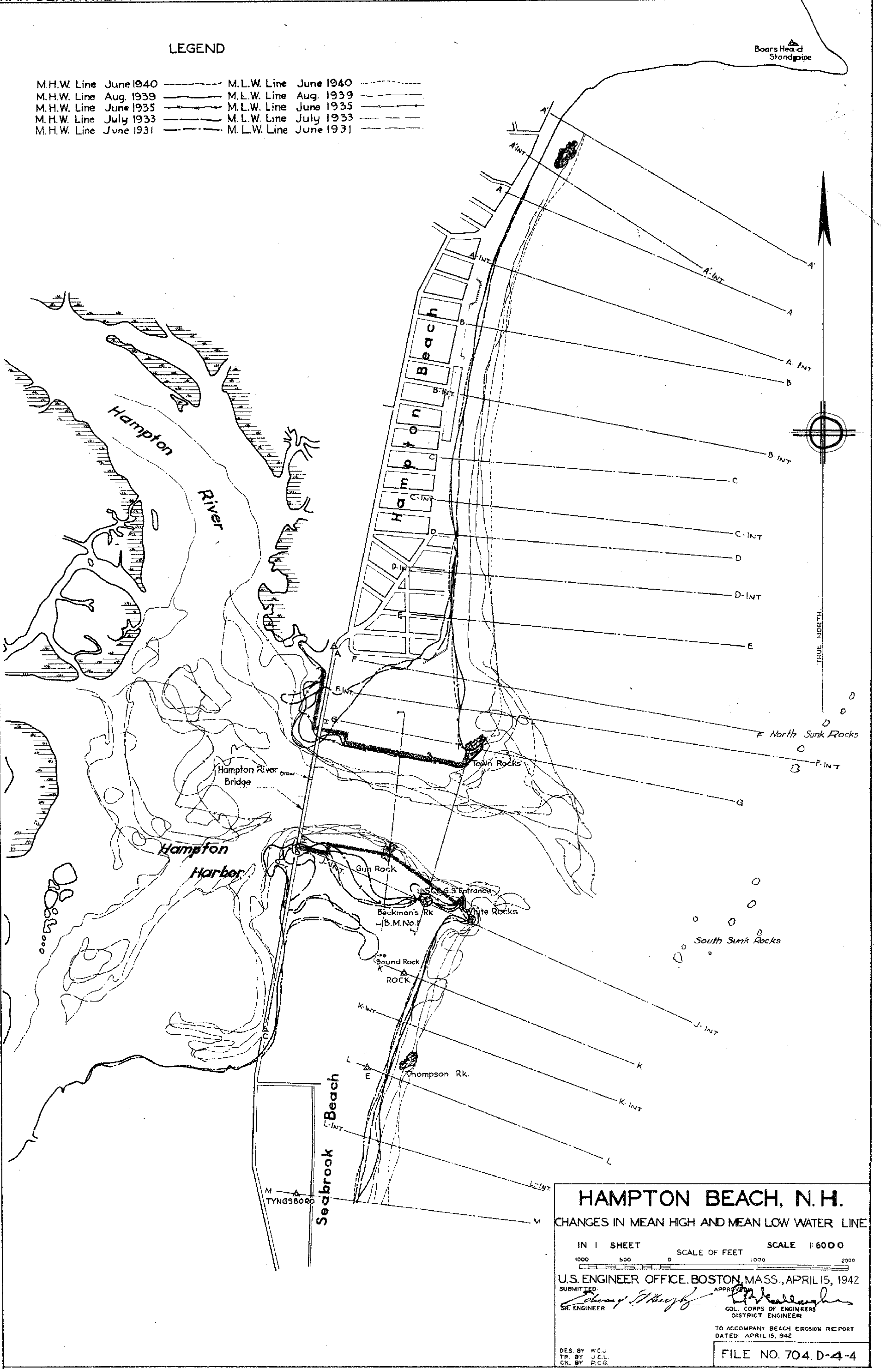
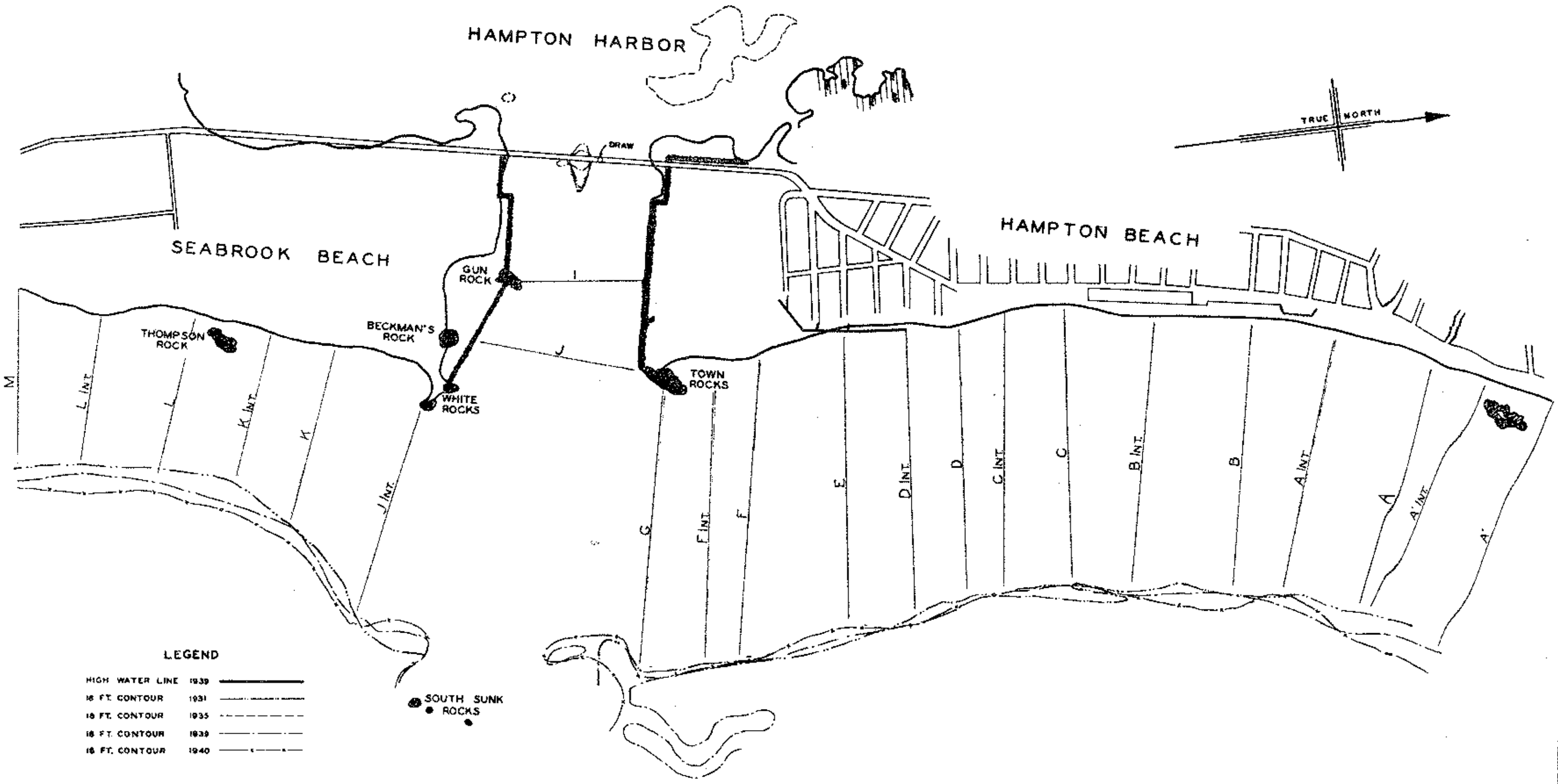
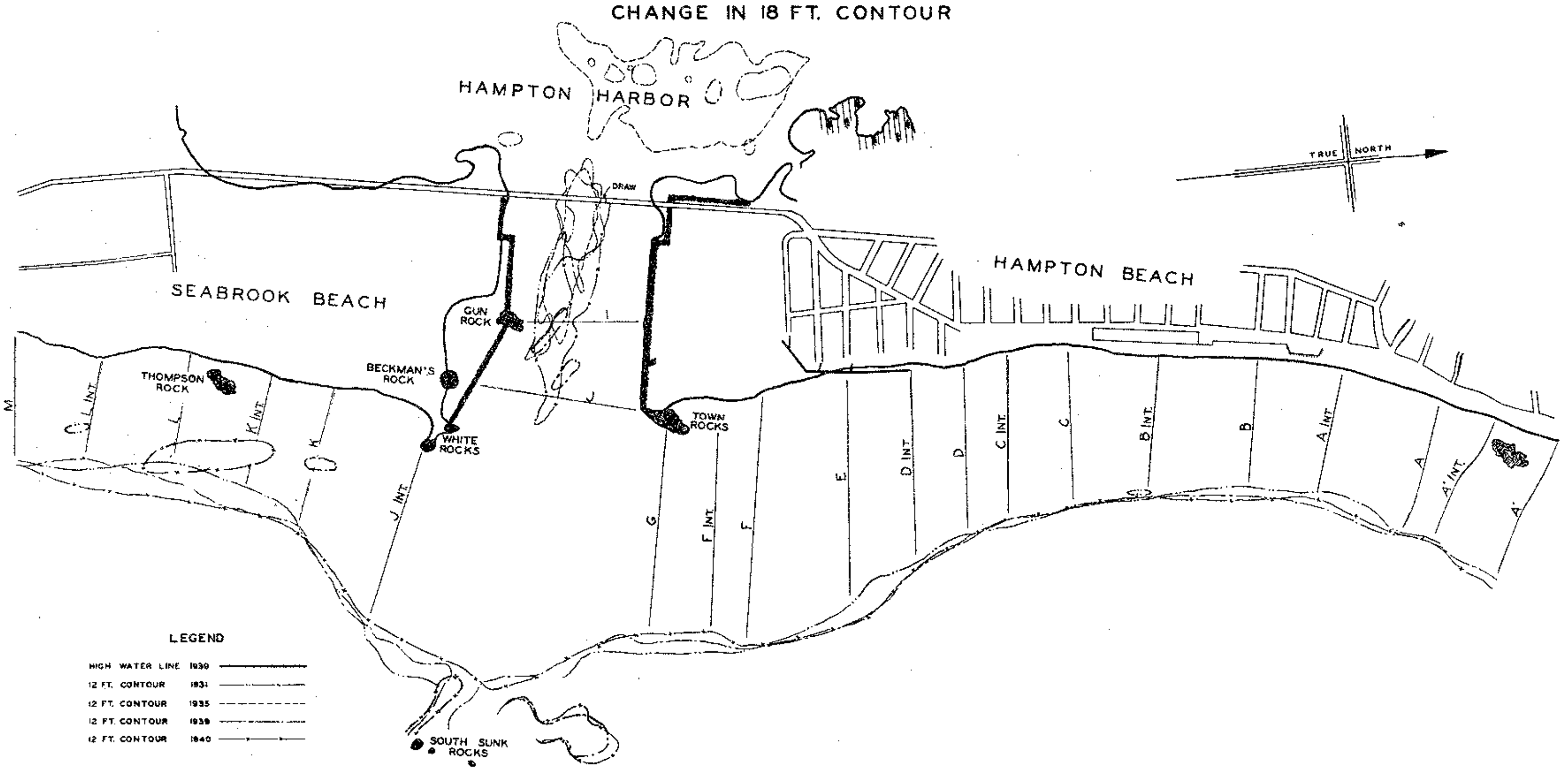


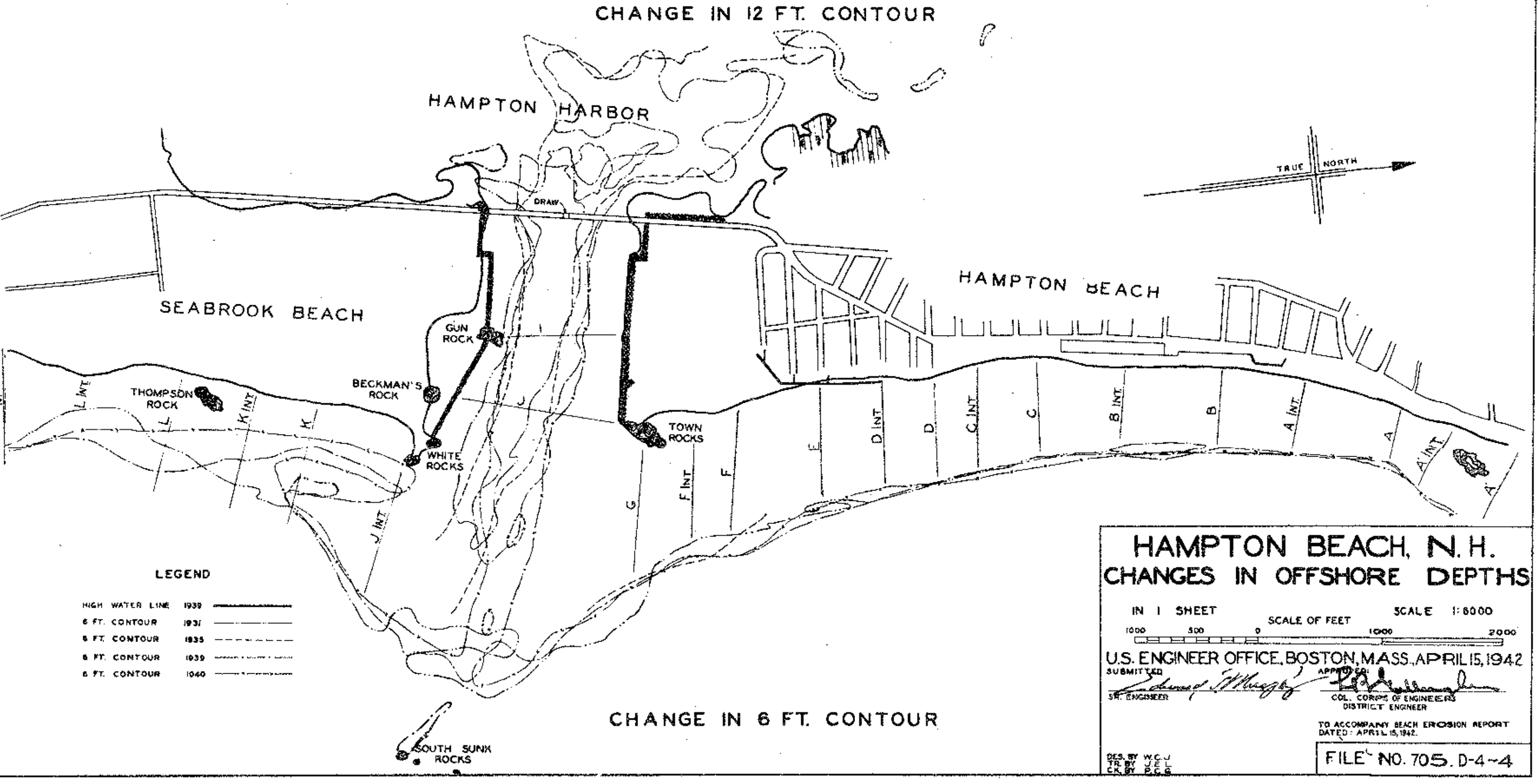
PLATE 3



CHANGE IN 18 FT. CONTOUR



CHANGE IN 12 FT. CONTOUR



CHANGE IN 6 FT. CONTOUR

HAMPTON BEACH, N.H.
CHANGES IN OFFSHORE DEPTHS

IN 1 SHEET SCALE 1:8000

SCALE OF FEET 1000 500 0 1000 2000

U.S. ENGINEER OFFICE, BOSTON, MASS., APRIL 15, 1942

SUBMITTED: SR. ENGINEER APPROVED: COL., CORPS OF ENGINEERS, DISTRICT ENGINEER

TO ACCOMPANY BEACH EROSION REPORT DATED: APRIL 15, 1942.

DES. BY W.C.J. TR. BY ... CK. BY ...

FILE NO. 705. D-4-4

CORPS OF ENGINEERS

U.S. ARMY

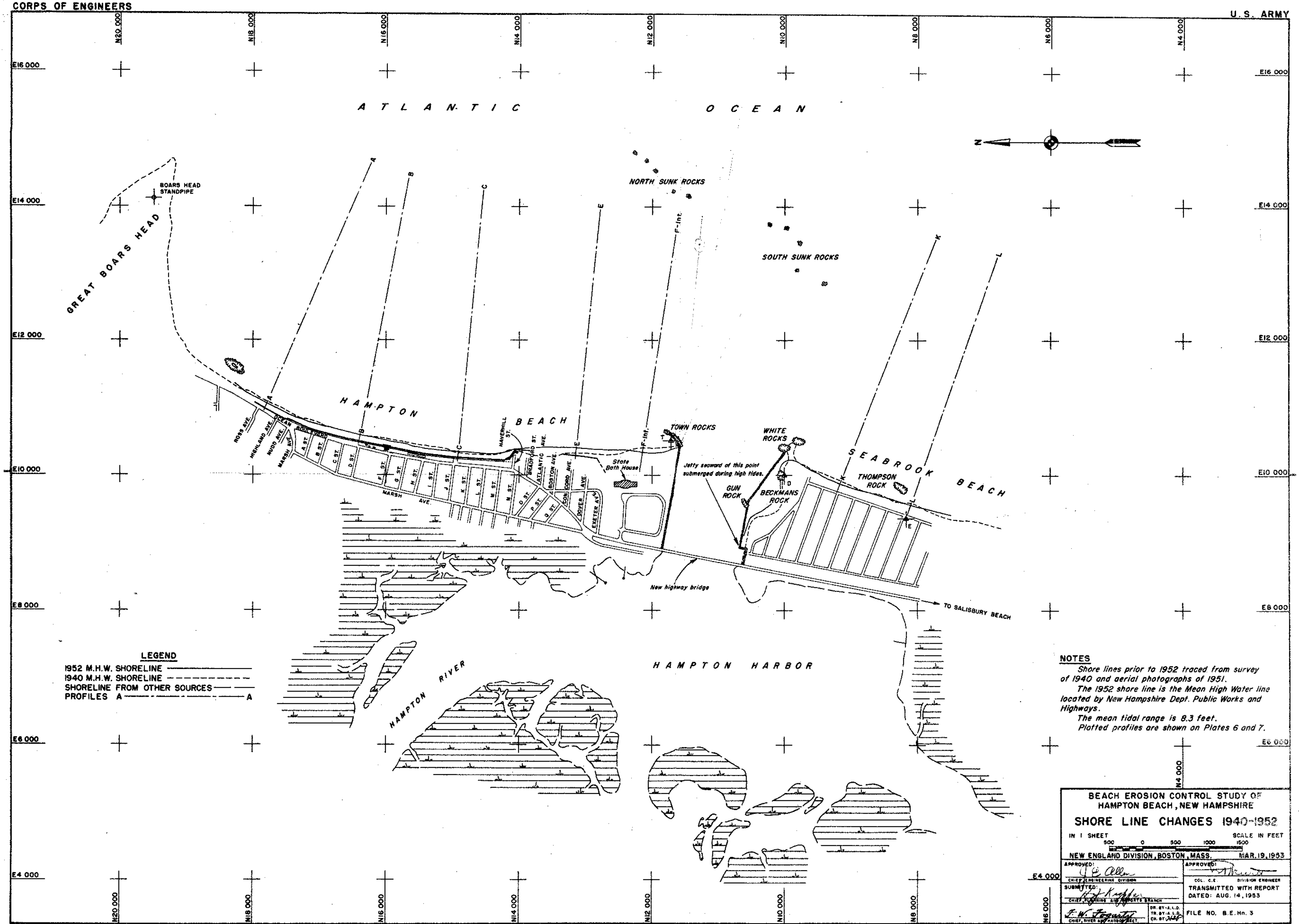
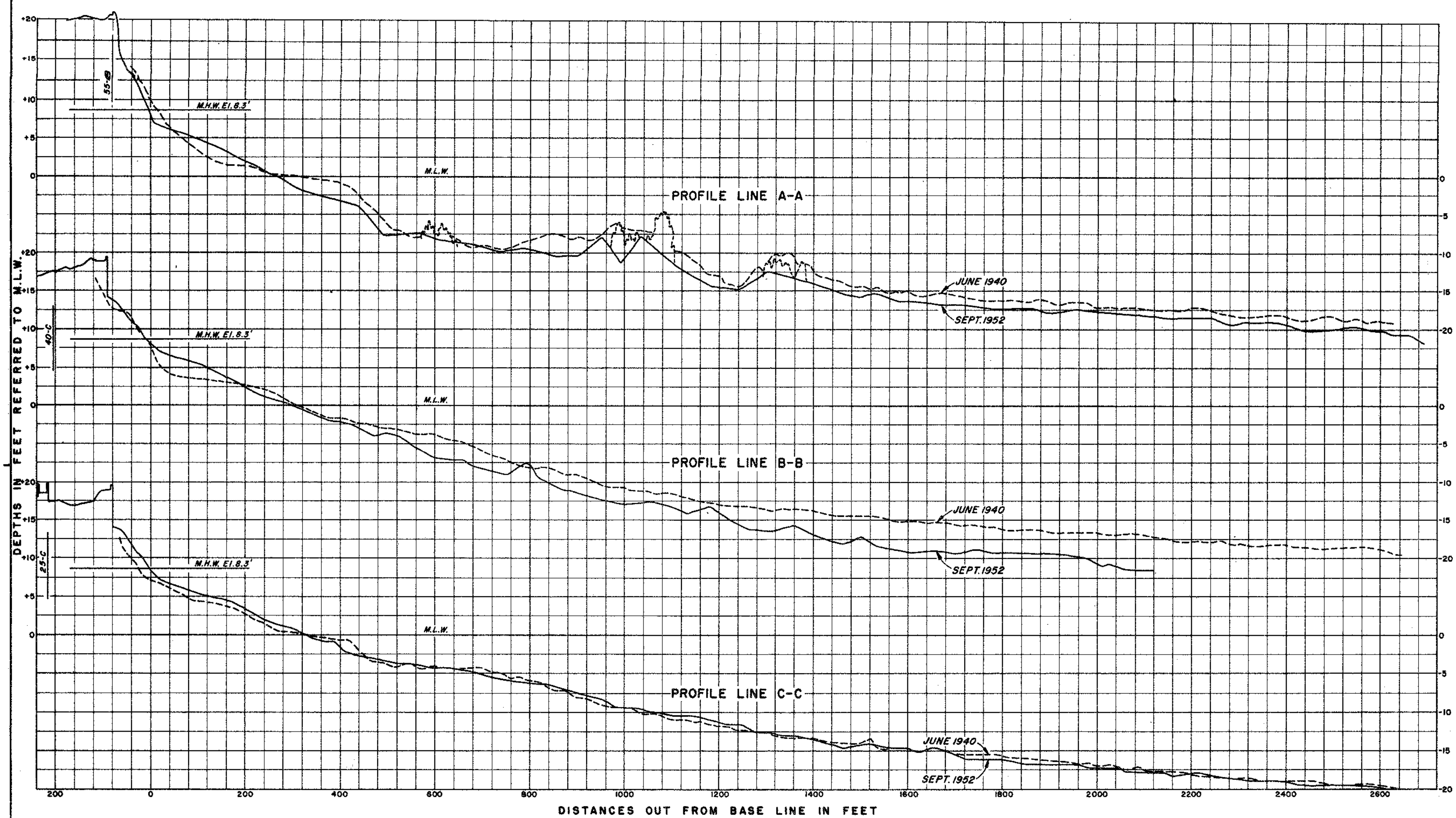


PLATE 5



NOTE

Locations of profiles are shown on Plate 5.

BEACH EROSION CONTROL STUDY OF HAMPTON BEACH, NEW HAMPSHIRE

COMPARATIVE PROFILES

IN 2 SHEETS SCALES AS SHOWN SHEET 1

NEW ENGLAND DIVISION, BOSTON, MASS. MAR. 23, 1953

APPROVED: CHIEF, ENGINEERING DIVISION

APPROVED: COL. C.E. DIVISION ENGINEER

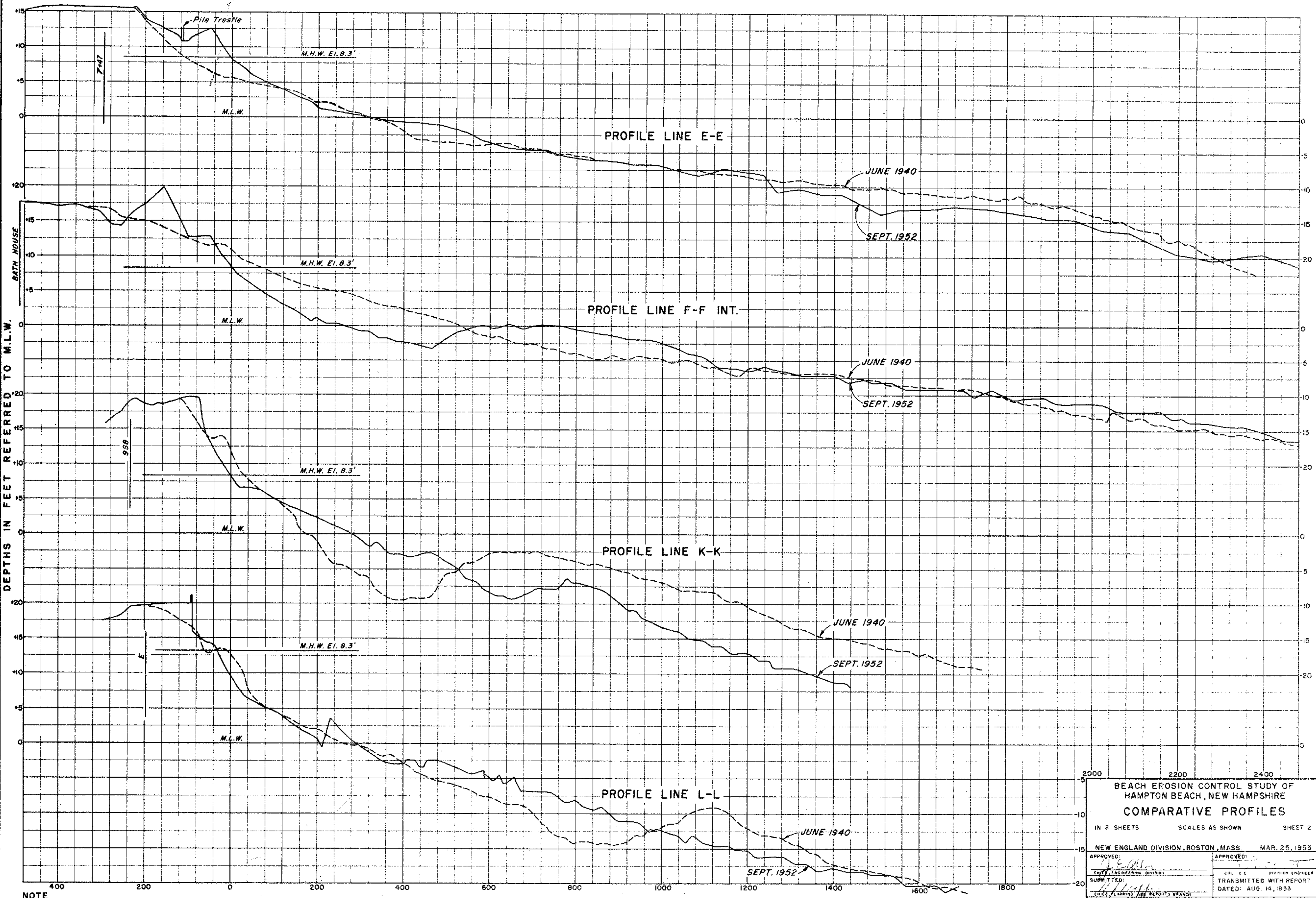
SUBMITTED: CHIEF, PLANNING AND REPORTS BRANCH

F. W. Fogarty CHIEF, RIVER AND HARBOR SECT.

DR. BY: A.L.D. TR. BY: A.L.C. CK. BY:

TRANSMITTED WITH REPORT DATED: AUG. 14, 1953

FILE NO. B.E. Hn. 4



NOTE
Locations of profiles are shown on Plate 5.

BEACH EROSION CONTROL STUDY OF
HAMPTON BEACH, NEW HAMPSHIRE

COMPARATIVE PROFILES

IN 2 SHEETS — SCALES AS SHOWN — SHEET 2

NEW ENGLAND DIVISION, BOSTON, MASS. — MAR. 25, 1953

APPROVED: CHIEF, ENGINEERING DIVISION

APPROVED: COL. C.E. DIVISION ENGINEER

SUBMITTED: CHIEF, PLANNING AND REPORTS BRANCH

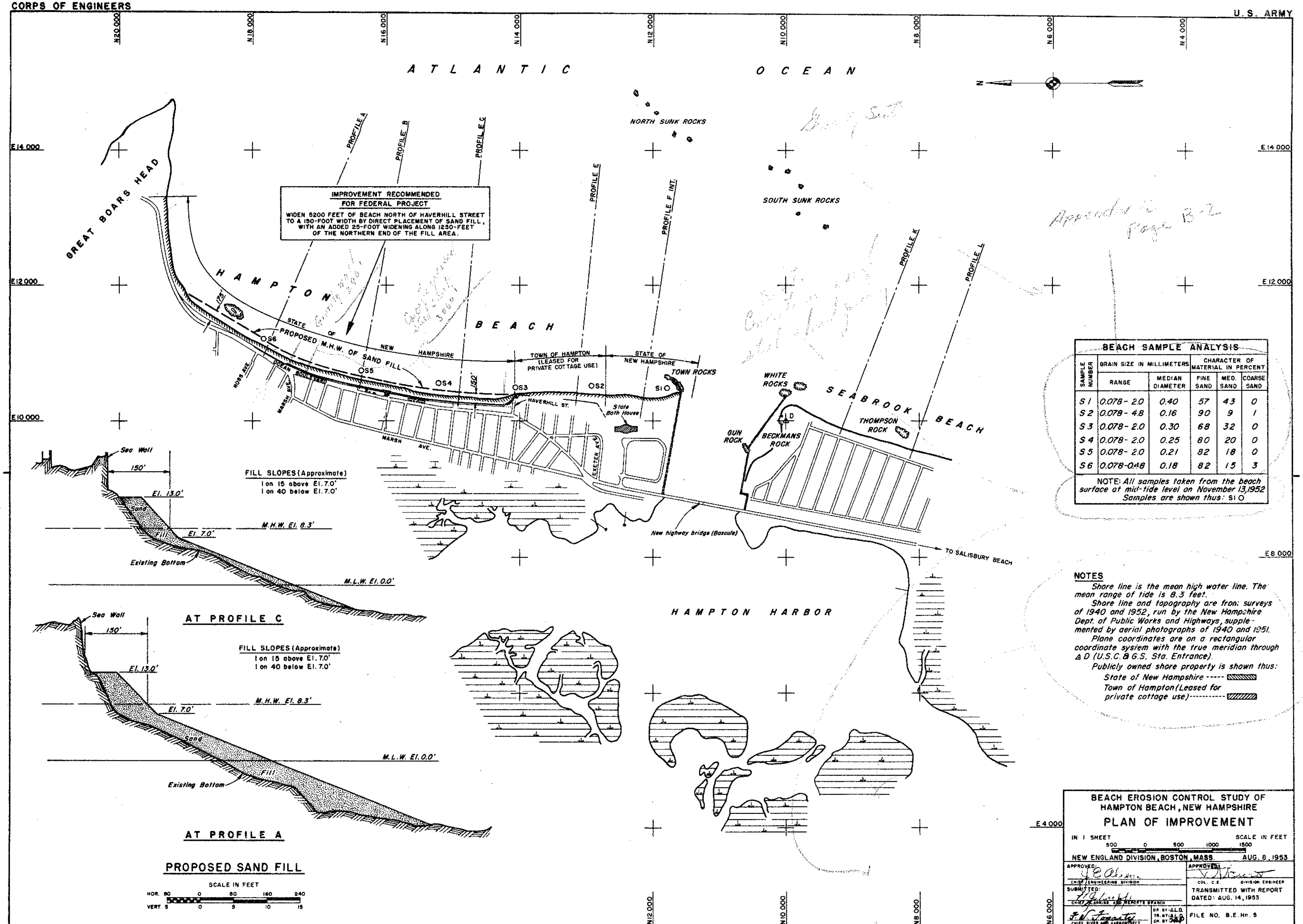
TRANSMITTED WITH REPORT DATED: AUG. 14, 1953

F.W. Fogarty — CHIEF, RIVER AND HARBOR SECT.

FILE NO. B.E. Hn. 4

CORPS OF ENGINEERS

U. S. ARMY



BEACH SAMPLE ANALYSIS

SAMPLE NUMBER	GRAIN SIZE IN MILLIMETERS		CHARACTER OF MATERIAL IN PERCENT		
	RANGE	MEDIAN DIAMETER	FINE SAND	MED. SAND	COARSE SAND
S 1	0.078 - 2.0	0.40	57	43	0
S 2	0.078 - 4.8	0.16	90	9	1
S 3	0.078 - 2.0	0.30	68	32	0
S 4	0.078 - 2.0	0.25	80	20	0
S 5	0.078 - 2.0	0.21	82	18	0
S 6	0.078 - 0.48	0.18	82	15	3

NOTE: *All samples taken from the beach surface at mid-tide level on November 13, 1952. Samples are shown thus:* S1 O

NOTES

Shore line is the mean high water line. The mean range of tide is 8.3 feet.

Shore line and topography are from surveys of 1940 and 1952, run by the New Hampshire Dept. of Public Works and Highways, supplemented by aerial photographs of 1940 and 1951.

Plane coordinates are on a rectangular coordinate system with the true meridian through △ D (U.S.C. & G.S. Sta. Entrance).

Publicly owned shore property is shown thus:

State of New Hampshire -----

Town of Hampton (Leased for private cottage use) ----------

BEACH EROSION CONTROL STUDY OF HAMPTON BEACH, NEW HAMPSHIRE

PLAN OF IMPROVEMENT

IN 1 SHEET — SCALE IN FEET 500 0 500 1000 1500

NEW ENGLAND DIVISION, BOSTON, MASS. AUG. 8, 1953

APPROVED: J. C. Alison — CHIEF, ENGINEERING DIVISION

SUBMITTED: [signature] — CHIEF, PLANNING AND REPORTS BRANCH

F. W. Fogarty — CHIEF, RIVER AND HARBOR SECT.

DR. BY: A.L.D. TR. BY: A.L.D. CH. BY: [initials]

APPROVED: [signature] — COL. C.E. DIVISION ENGINEER

TRANSMITTED WITH REPORT DATED: AUG. 14, 1953

FILE NO. B.E. Hn. 5

PLATE 8